



BARCELONA
SCHOOL OF
MANAGEMENT

Ethics of Quantification

Andrea Saltelli

Course Theory of Science and Ethics (MNF990),
February 19, 2025



Where to find this talk: www.andreasaltelli.eu



HOME ABOUT ME PUBLICATIONS NEWS & VIDEOS RESOURCES



August 25 2023: The politics of modelling is out!



Praise for the volume

"A long awaited examination of the role —and obligation —of modeling."

Nassim Nicholas Taleb, Distinguished Professor of Risk Engineering, NYU Tandon School of Engineering. Author, of the 5 -volume series *Incerto*.

"A breath of fresh air and a much needed cautionary view of the ever-widening dependence on mathematical modeling."

Orrin H. Pilkey, Professor at Duke University's Nicholas School of the Environment, co-author with Linda Pilkey-Jarvis of *Useless Arithmetic: Why Environmental Scientists Can't Predict the Future*, Columbia University Press 2009.

"The methods by which power insinuates itself

Mastodon Toots by

@AndreaSaltelli



AndreaSaltelli

2023/8/28 11:24

August 26 Podcast (16m) - interview for ABC NET RADIO, AUS: Assumptions and consequences: the politics of modelling, Guests: Ehsan Nabavi and Andrea Saltelli, Producer - Chris Bullock.

abc.net.au/listen/programs/sun

View on mstdn.social

I am also interested in the cake

...things don't become too black or white

I am just getting to know how things are in research

relationship between science, ethics, and society

uncertainties in statistical work

a good chemist and a better human being

basic theories and different schools of thought in ethics

reflect on my own role as a researcher

ethical dilemmas in mathematics

healthy cooperations and collaborations rather than unhealthy competitions

ethical concern in using AI tools for research

working with p-values



ethical scientific

research

science

ai

thought

integrity

researcher

using

philosophy

responsibilities

ethics

dilemmas

scientists

face

society's

good

understanding

better

society

cooperations

questions

step

findings

back

study

disciplines

social

different

include

animals

knowledge

sure

use

things

ethical

scientific

a good chemist and a better human being

ethical concern in using AI tools for research

working with p-values

healthy cooperations and collaborations rather than unhealthy competitions



Outline

- Fantastic numbers
- Stern controversy
- Crosby
- Sociology of quantification
- Porter, trust, Luhmann, Ravetz
- Goodhart, Ravetz
- O'Neil, Coded bias
- Zuboff, Social Dilemma
- Supiot
- Economists
- Muller's Tyranny of metrics
- Statactivism
- Modelling Manifesto
- Beck, Majone
- Salais, Desrosières
- Thévenot
- Scoones, Stirling
- Fishing Expeditions, Forking Paths
- Digital Twins of the Earth

… our world is structured by numbers, visible and invisible, where truth is conveyed and reality constructed

Numbers are seductive, performative, confer to their masters' epistemic power and legitimacy

Governing the modern state, or even contesting it, without numbers is impossible

Numbers are the prevalent means to express value in our societies
… Access & production of numbers reflect and reinforce power imbalances

Source: Saltelli, A., Andreoni, A., Drechsler W., Ghosh, J., Kattel, R., Kvangraven, I. H., Rafols, I., Reinert, E. S., Stirling, A. and Xu, T. (2021). Why ethics of quantification is needed now. UCL Institute for Innovation and Public Purpose, Working Paper Series (IIPP WP 2021/05)
<https://www.ucl.ac.uk/bartlett/public-purpose/publications/2021/jan/why-ethics-quantification-needed-now>.



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WORKING PAPER
WP 2021/05

Numbers capture our attention; they illuminate the part of reality which is being numerified, and fatally push those parts into the background which come without the clothing of ...

... numbers are so deeply entrenched in our existence that we barely reflect on them critically them anymore — too close to us, they have become part of the very lens through which we attend to and comprehend the world.

Source: Saltelli, A., Andreoni, A., Drechsler W., Ghosh, J., Kattel, R., Kvangraven, I. H., Rafols, I., Reinert, E. S., Stirling, A. and Xu, T. (2021). Why ethics of quantification is needed now. UCL Institute for Innovation and Public Purpose, Working Paper Series (IIPP WP 2021/05)
<https://www.ucl.ac.uk/bartlett/public-purpose/publications/2021/jan/why-ethics-quantification-needed-now>.



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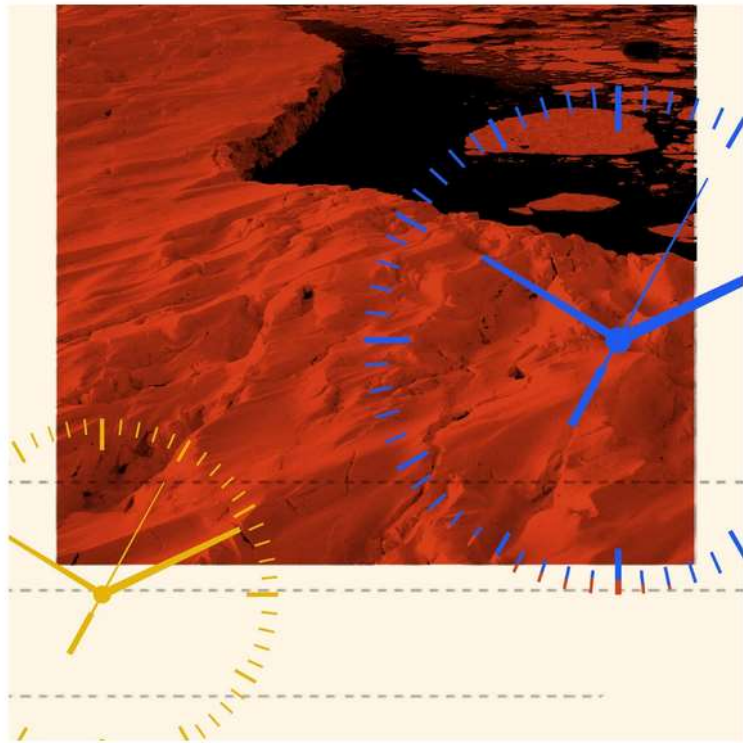
WORKING PAPER
WP 2021/05

Do we live immersed in
fantastic numbers?

OPINION
PETER COY

‘The Most Important Number You’ve Never Heard Of’

Sept. 17, 2021



“social cost of carbon:

=\$56 a ton on average at a 3 percent discount rate

=\$171 a ton on average at a 2 percent discount rate”

The New York Times


Social cost of carbon estimates have increased over time

Richard S. J. Tol

Received: 3 August 2022

Accepted: 23 April 2023

Published online: 15 May 2023


 Check for updates

Mathematical models predicting the damage in dollars from hurricanes and draughts up to the year 2300

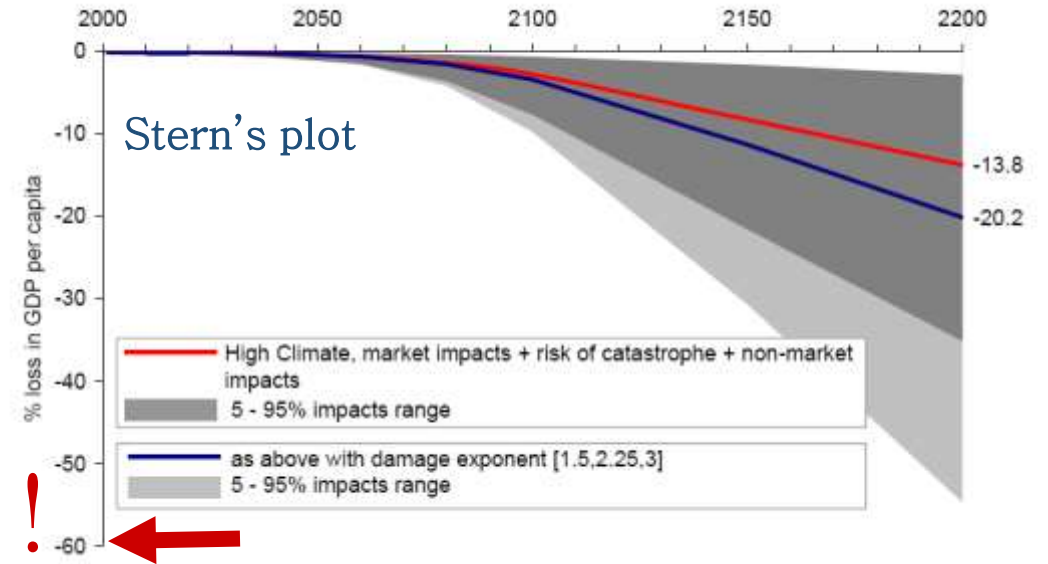
The Social Cost of Carbon: Advances in Long-Term Probabilistic Projections of Population, GDP, Emissions, and Discount Rates

Kevin Rennert, Brian C. Prest, William A. Pizer, Richard G. Newell, David Anthoff, Cora Kingdon, Lisa Rennels, Roger Cooke, Adrian E. Raftery, Hana Ševčíková, and Frank Errickson

Working Paper 21-28
October 2021



The Stern–Nordhaus controversy;
 a reverse engineering the model:
 → uncertainty is too large to take
 decisions → both Stern and
 Nordhaus are wrong



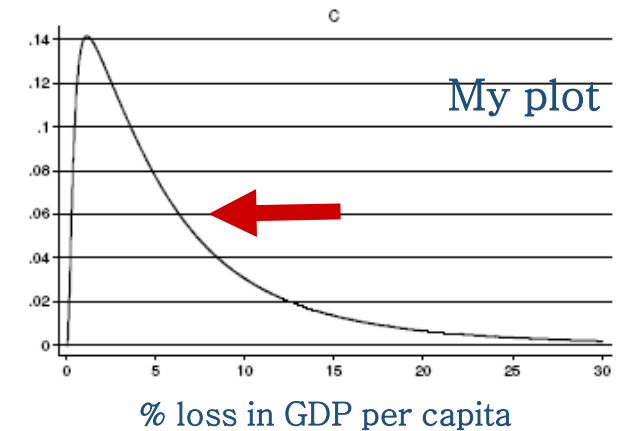
Global Environmental Change 20 (2010) 298–302



Contents lists available at ScienceDirect

Global Environmental Change

journal homepage: www.elsevier.com/locate/gloenvcha

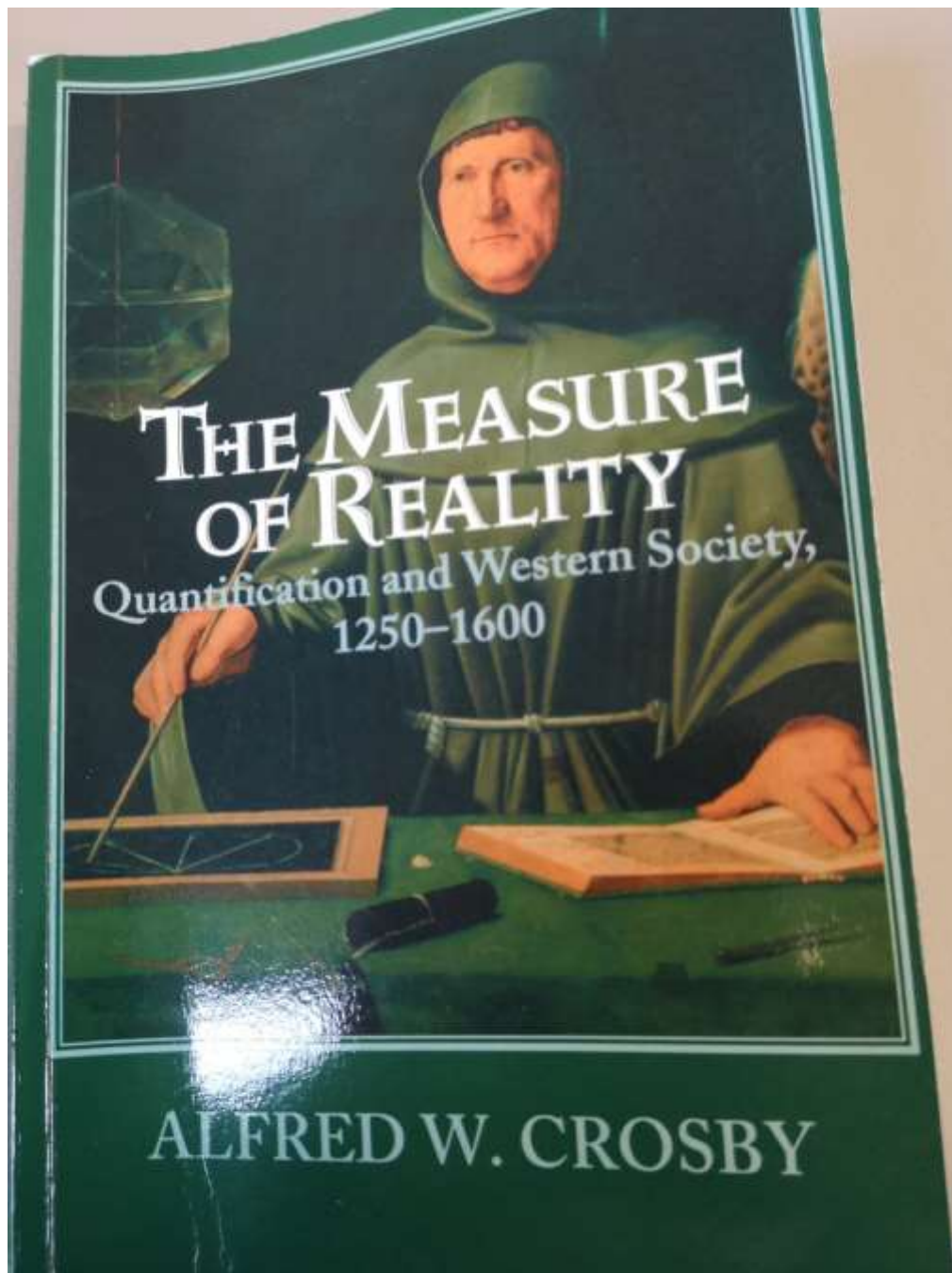


Sensitivity analysis didn't help. A practitioner's critique of the Stern review

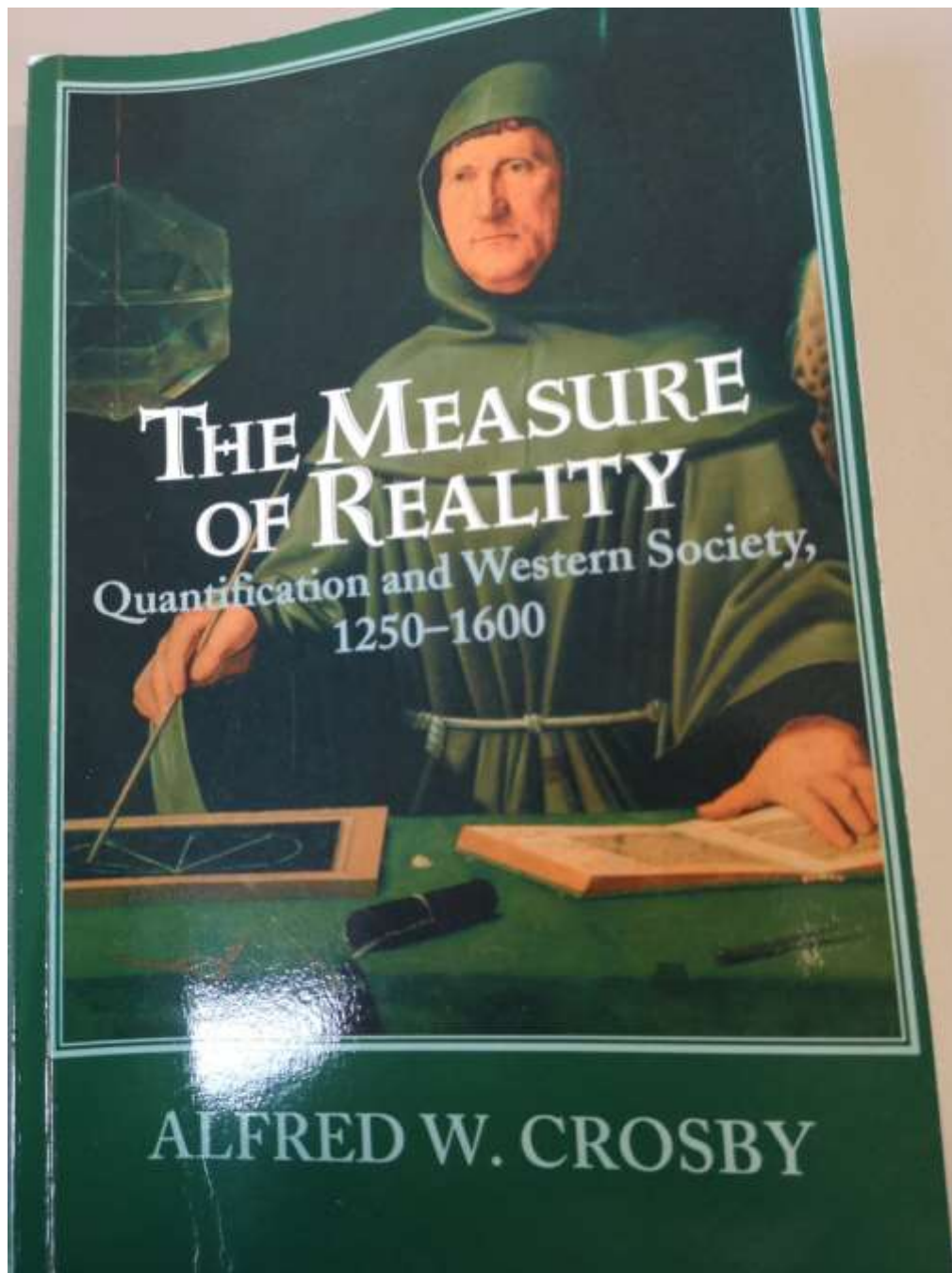
Andrea Saltelli *, Beatrice D'Hombres

Joint Research Centre, Institute for the Protection and Security of the Citizen, Ispra, Italy

How did we get there?



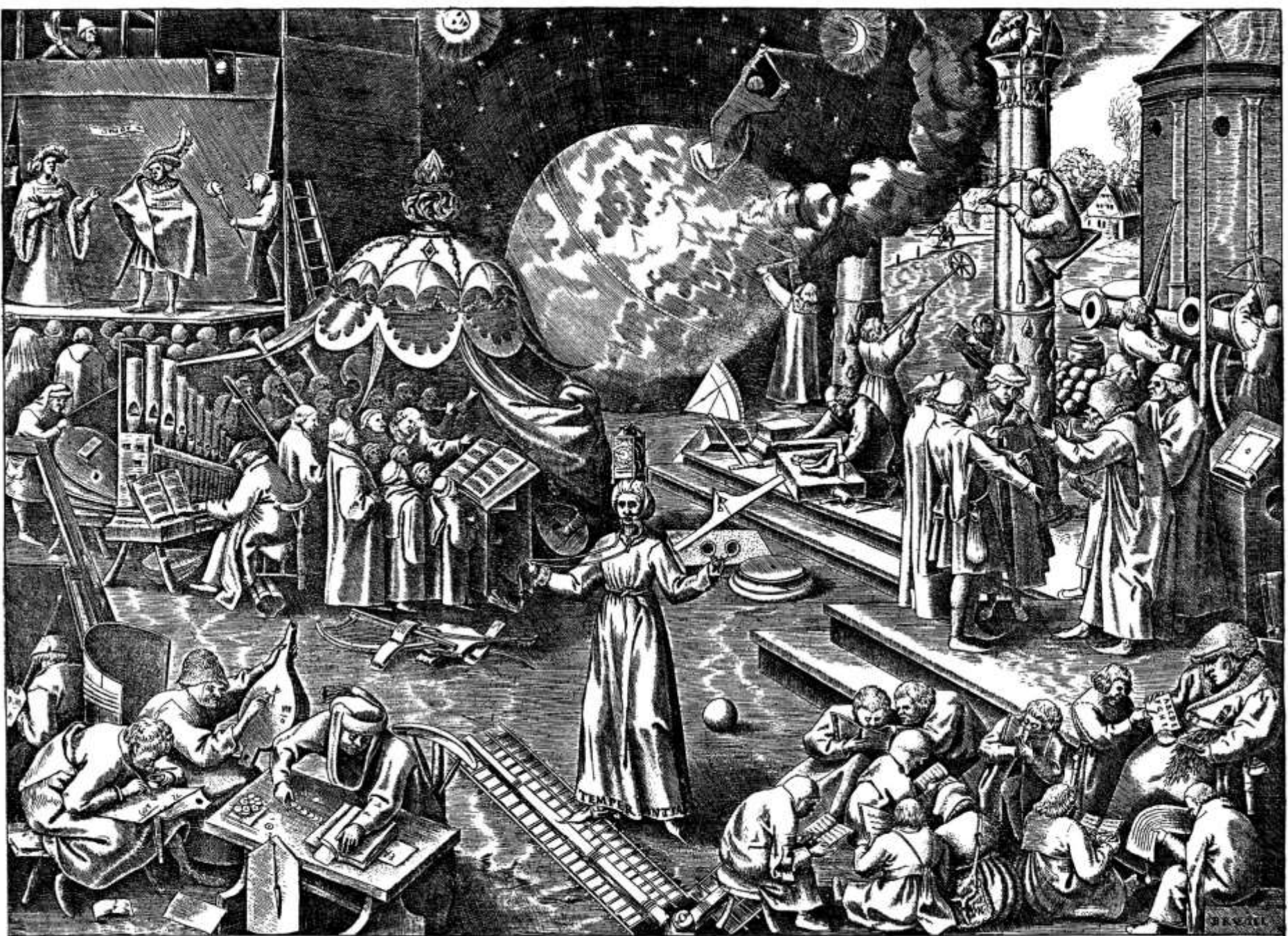
Were quantification and visualization the engine inside the engine of western success and domination?



Quantification and visualization of space and time gave rise in the XIV century to a true revolution, in music, painting, accounting, cartography, astronomy ...

Pieter Bruegel the Elder, Temperance, 1560

Measuring:
military
technology,
accounting,
perspective,
polyphonic
music, the
windmill,
the watch ...



VIDENDVM, VT NEC VOLVPTATI DEDITI PRODIGI ET LVXVRIOSI
APPAREAMVS, NEC AVARA TENACITATI SORDIDI AVT OBCVRI EXISTAMVS





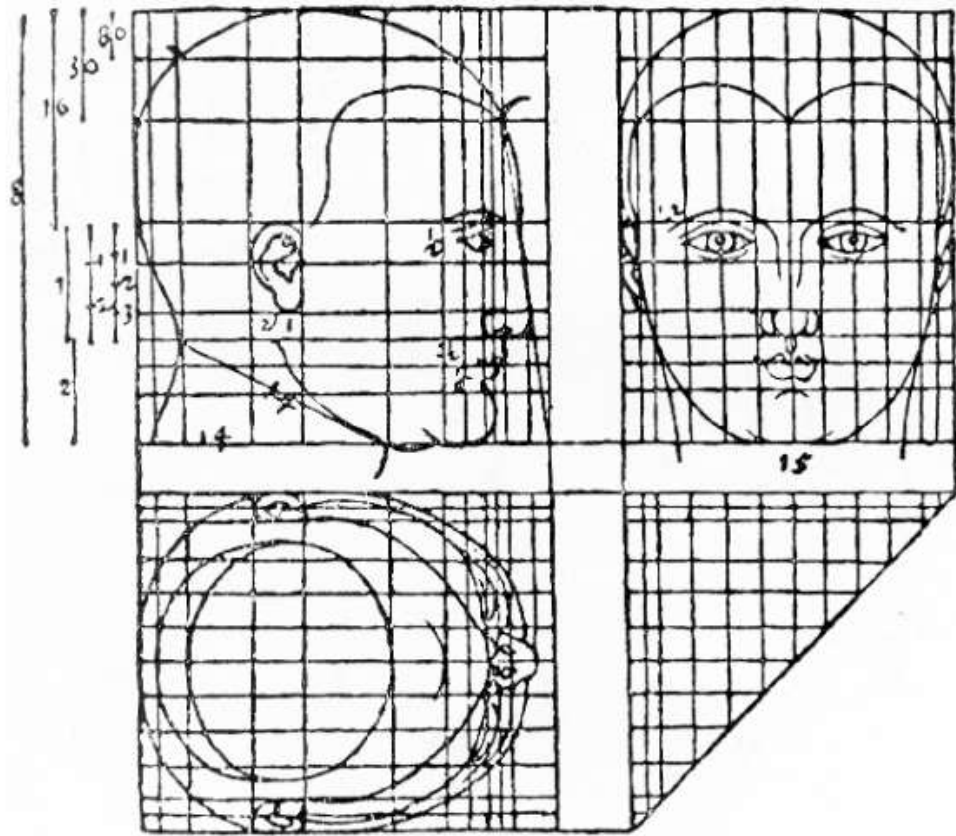
The Annunciation,
Carlo Crivelli
(1435, 1495)



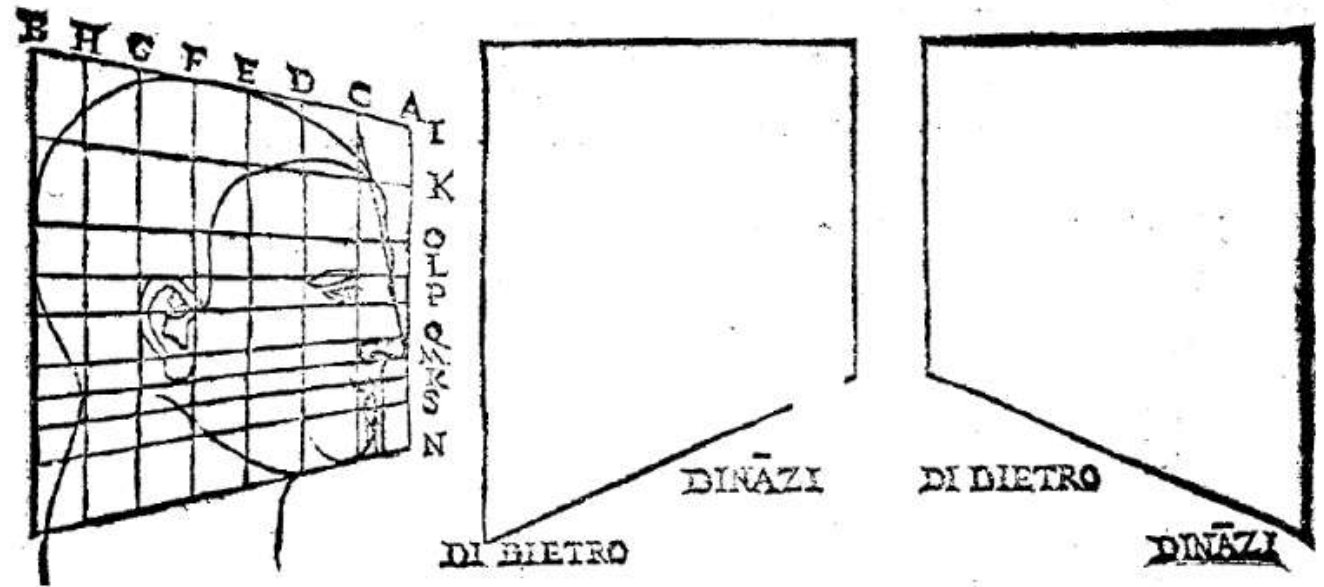


Draftsman Drawing a Reclining Nude
Albrecht Dürer (1471–1528)





DELLA SIMMETRIA



From “De Varietate figurarum”
Albrecht Dürer (1471–1528)



Many voices of alarm as to
misuse of quantification

With numbers both visible and
invisible...

Blurring lines:

“what qualities are specific to rankings, or indicators, or models, or algorithms?”



Elizabeth
Popp Berman

E. Popp Berman and D. Hirschman, **The Sociology of Quantification**: Where Are We Now?, *Contemp. Sociol.*, vol. in press, 2017.

Numbers, visible and invisible...



Publications A-Z

Journal Information

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ANNUAL REVIEW OF SOCIOLOGY Volume 45, 2019

Review Article | [Open Access](#)

What's New with Numbers? Sociological Approaches to the Study of Quantification

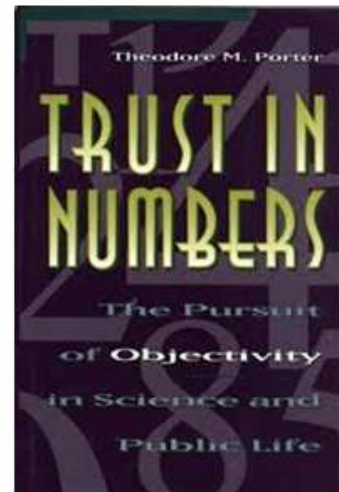
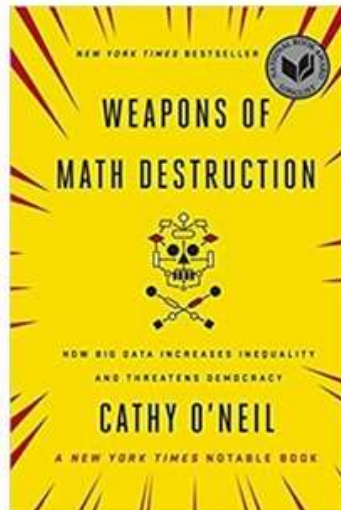
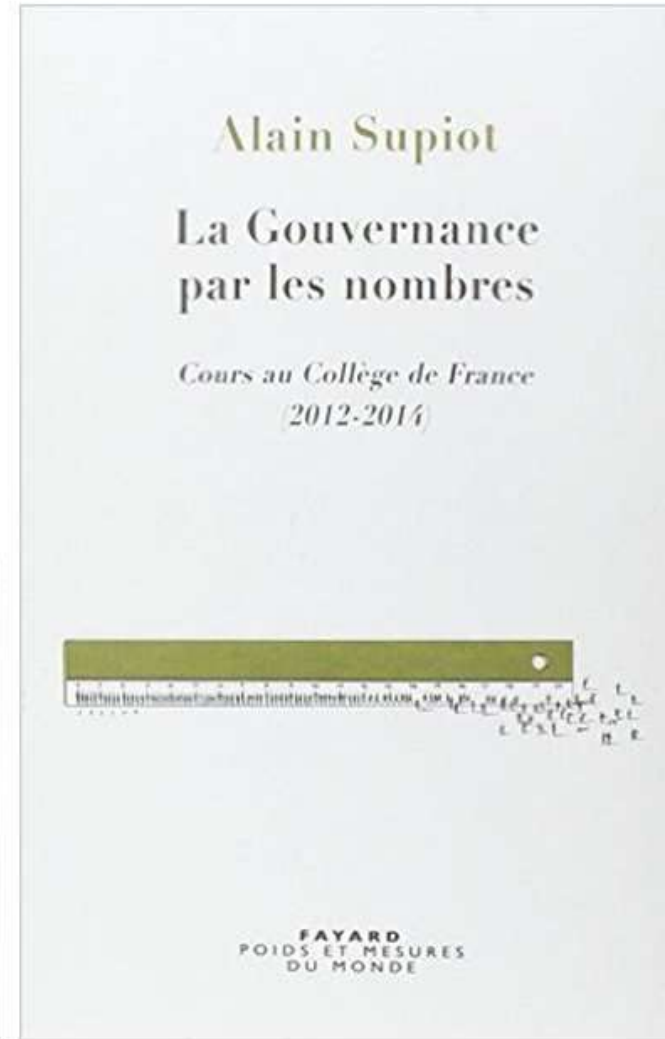
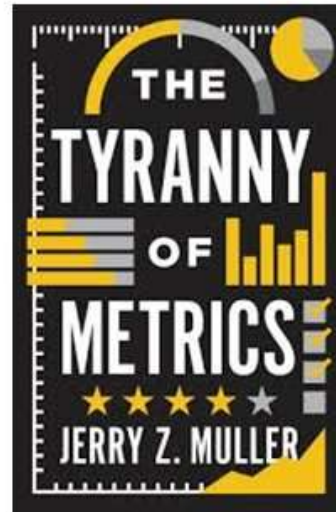
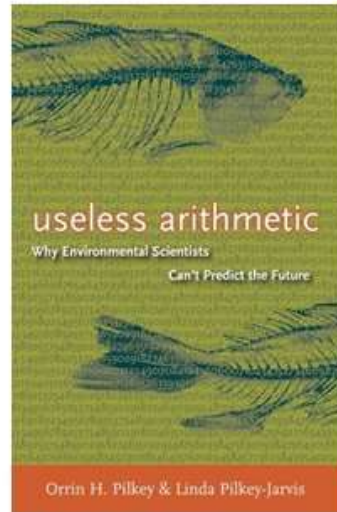
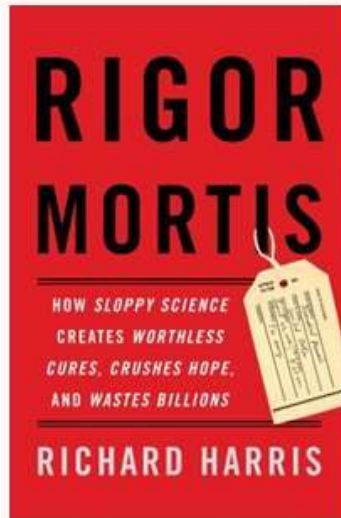
Andrea Mennicken¹, and Wendy Nelson Espeland²

[View Affiliations](#)

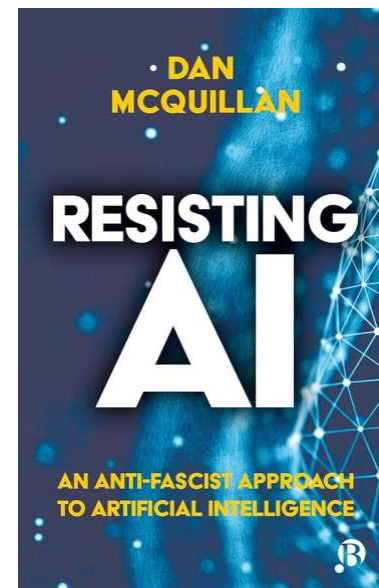
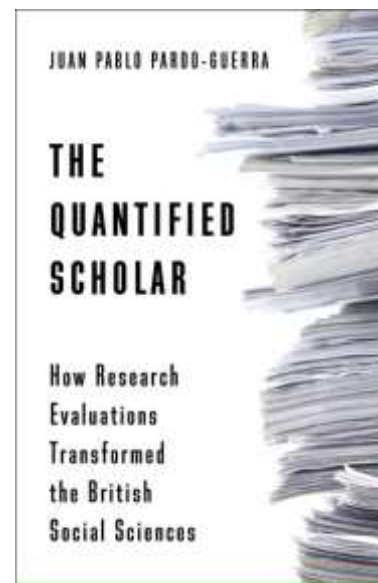
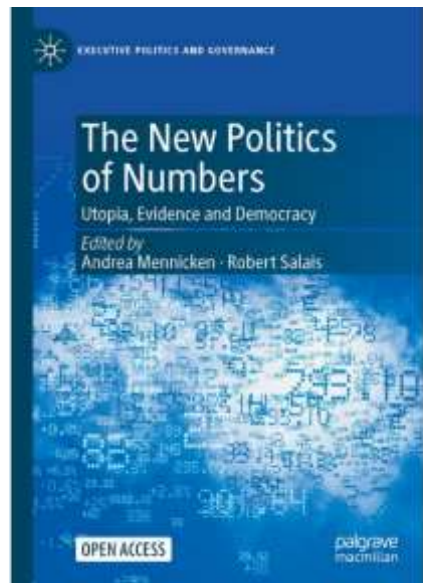
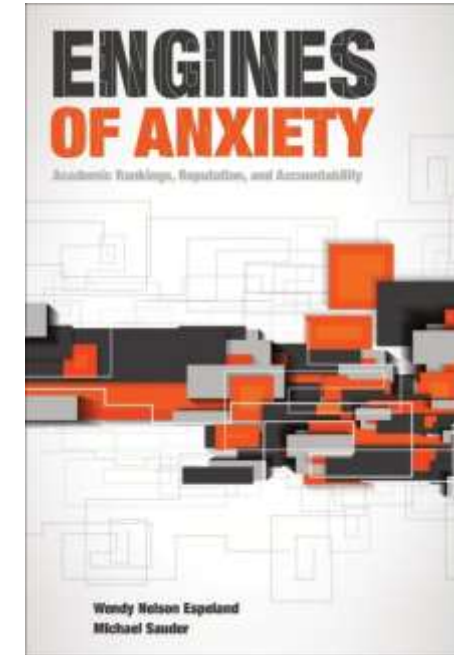
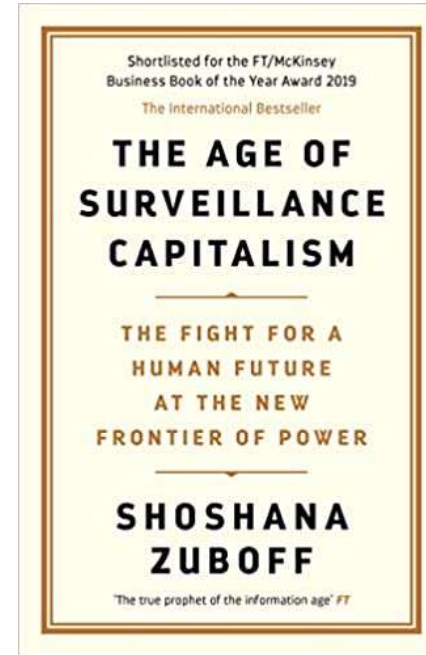
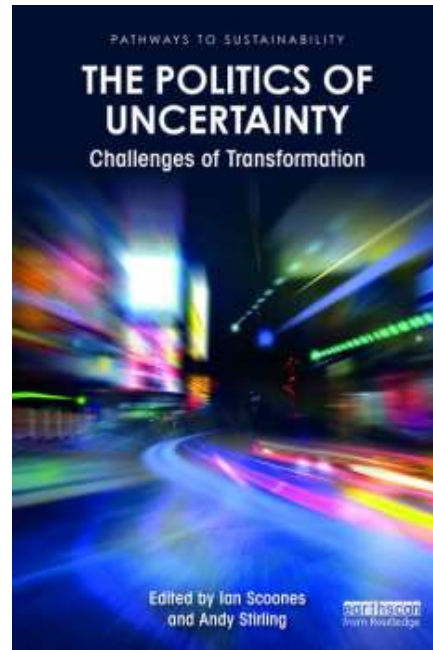
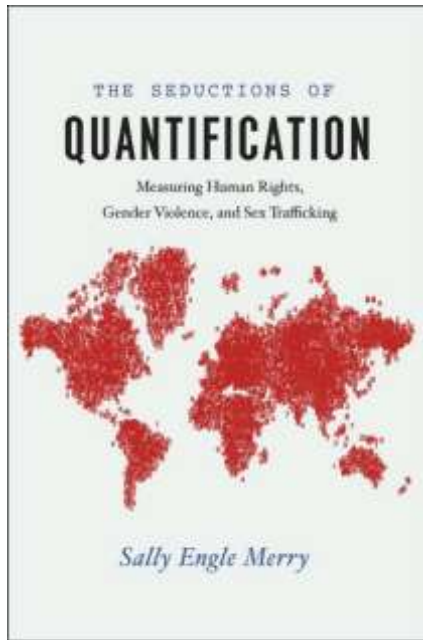
Vol. 45:223-245 (Volume publication date July 2019) | <https://doi.org/10.1146/annurev-soc-073117-041343>

First published as a Review in Advance on May 13, 2019

Algorithms, models, metrics, statistics...



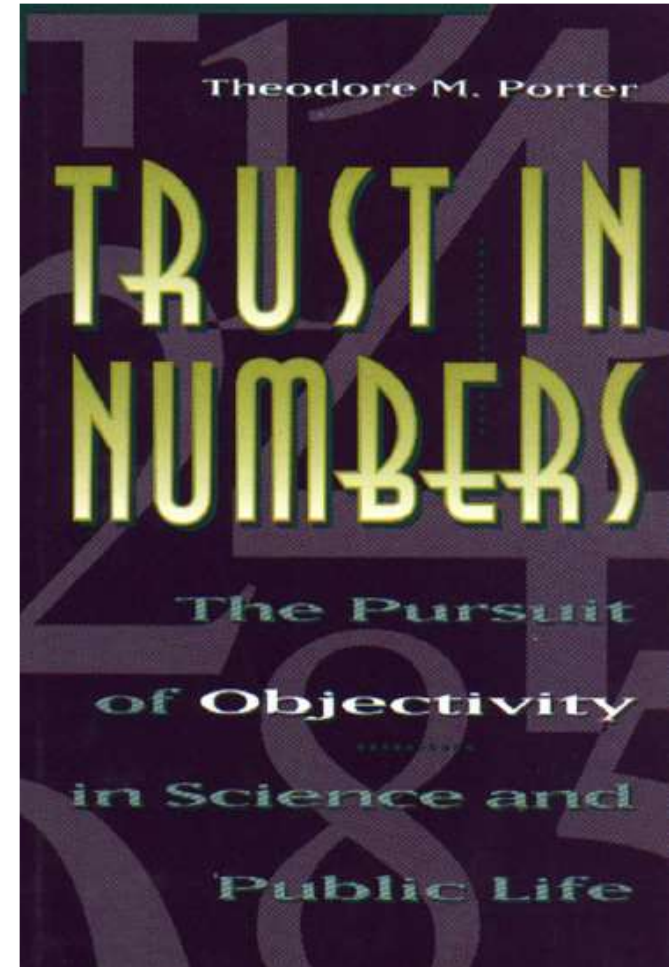
Algorithms, models, metrics, statistics...



Numbers and trust



Theodor
M. Porter



Theodore M. Porter, Trust in Numbers,
The Pursuit of Objectivity in Science and Public Life, Princeton 1995

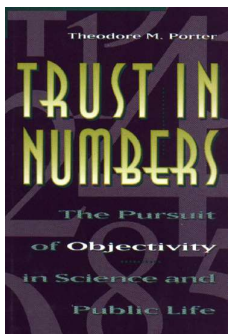
Porter's story: Quantification needs judgment which in turn needs trust ...without trust quantification becomes mechanical, a system, and 'systems can be played'.

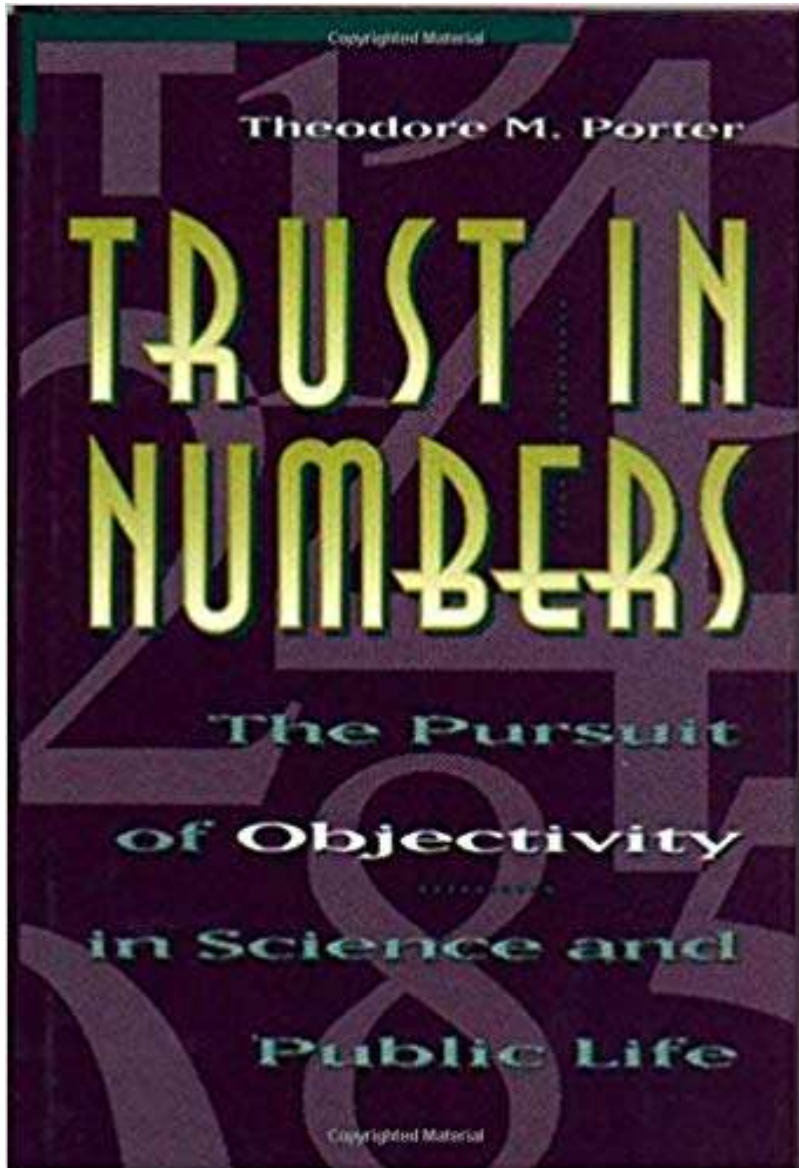


The appeal of numbers is especially compelling to bureaucratic officials who lack the mandate of a popular election, or divine right, p. 8

...

A decision made by the numbers (or by explicit rules of some other sort) has at least the appearance of being fair and impersonal, p. 8





Numbers are not neutral but their purported neutrality is a large part of their appeal: being performative without appearing to be so

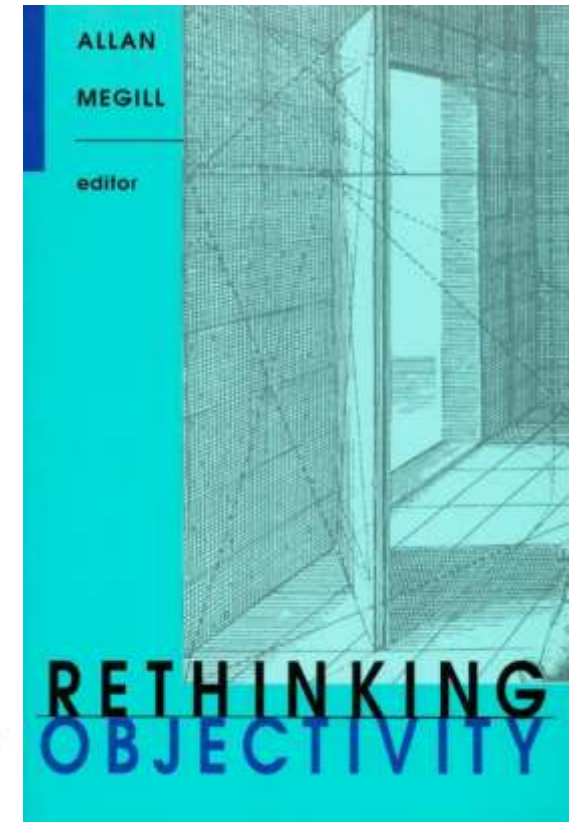
<http://ereserve.library.utah.edu/Annual/WRTG/3705/Mathison/objectivity.pdf> in



Objectivity as Standardization:
The Rhetoric of Impersonality in
Measurement, Statistics,
and Cost-Benefit Analysis

THEODORE M. PORTER

*1. Quantification makes knowledge impersonal,
hence objective.*



‘System trust’, is social system theory:

“The reduction of complexity
[made possible by generalized media of
communication as money, power and truth]
assumes trust on the part of those
who are expecting such reduction
and of those who are supposed to
accept it once it is accomplished”



Niklas Luhmann

N. Luhmann, Trust and Power. Polity Press, 2017.

‘the essential fiduciary status’ of science= Trust in science is necessary for the general society to continue to support it, materially and with recruits. And mutual trust within science is necessary for its systems of quality assurance to function



Jerome R.
Ravetz

For Ravetz (1971, pp. 295–296), when the goals of a task are complex, sophisticated, or subtle, then crude systems of measurements can be played exactly by those persons possessing the skills to execute the tasks properly, who thus manage to achieve their own goals to the detriment of those assigned.

Ravetz, J.R., 1971, *Scientific Knowledge and Its Social Problems*, 1996 Edition, Transaction Publishers. See examples in Muller, J.Z., 2018, *The Tyranny of Metrics*, Princeton.



Charles Goodhart

p. 44 “Any ... measures necessarily involve a loss of information ... [and distorts behavior]” (Porter, 1995)

This is what we normally call Goodhart’s law, from Charles Goodhart. “When a measure becomes a target, it ceases to be a good measure.”

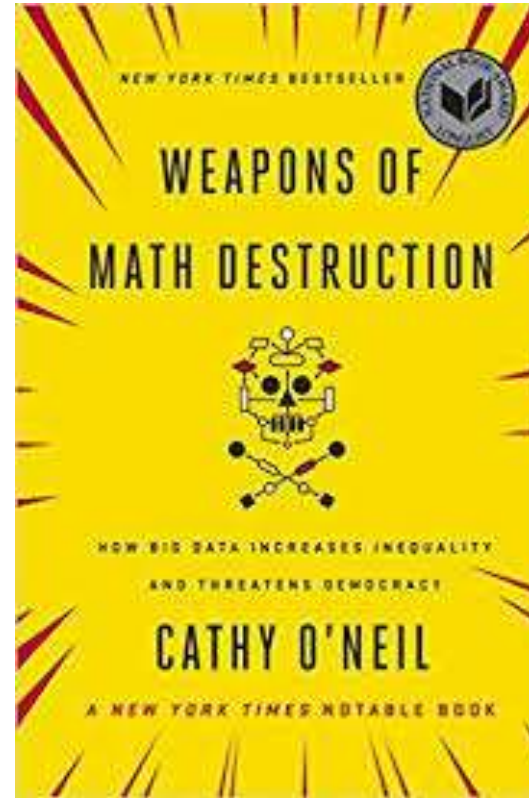
Also known as Campbell's law (1976);

https://en.wikipedia.org/wiki/Goodhart%27s_law

Alarm for Weapons of Math Destruction



Cathy O'Neil

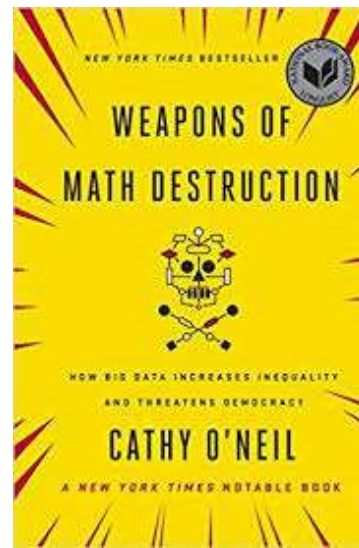


O'Neil, C. (2016). Weapons of math destruction : how big data increases inequality and threatens democracy. Random House Publishing Group.

Opacity (also because of trade secrecy) of algorithms used to decide on recruiting, carriers (including of researchers), prison sentencing, paroling, custody of minors, political campaigns...

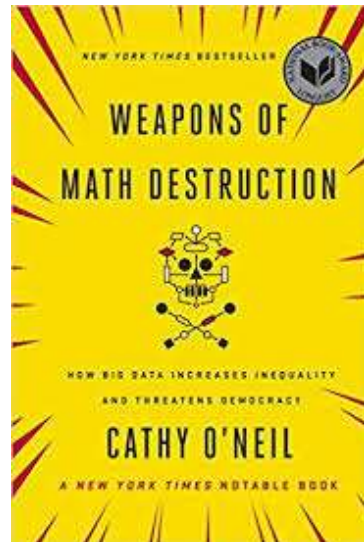
O'Neil, C. (2016). Weapons of math destruction : how big data increases inequality and threatens democracy. Random House Publishing Group.

Brauneis, R., & Goodman, E. P. (2018). Algorithmic Transparency for the Smart City. *Yale Journal of Law & Technology*, 20, 103–176. Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3012499



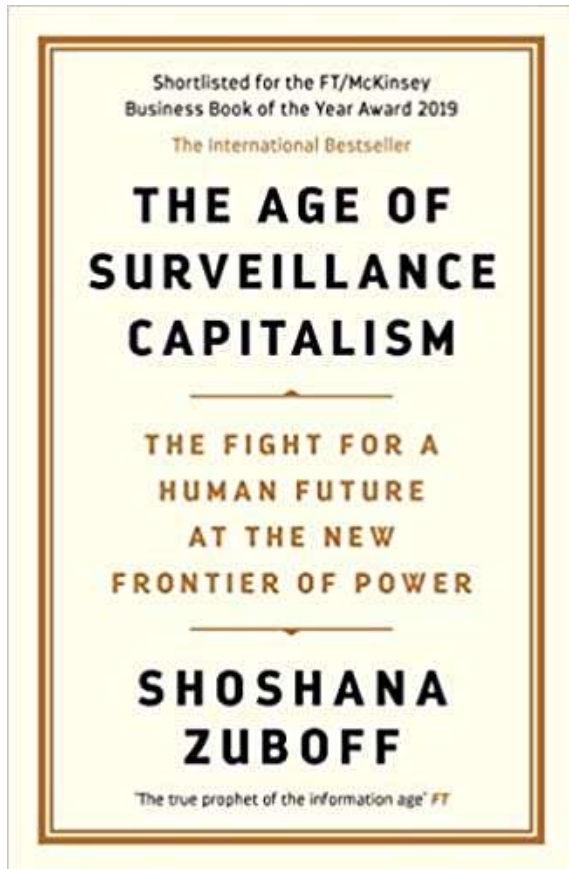
Opacity coupled with opportunity for scale and damage and with non-appealability make them an instrument of oppression & inequality

Cathy O'Neil Google talk <https://www.youtube.com/watch?v=TQHs8SA1qpk>





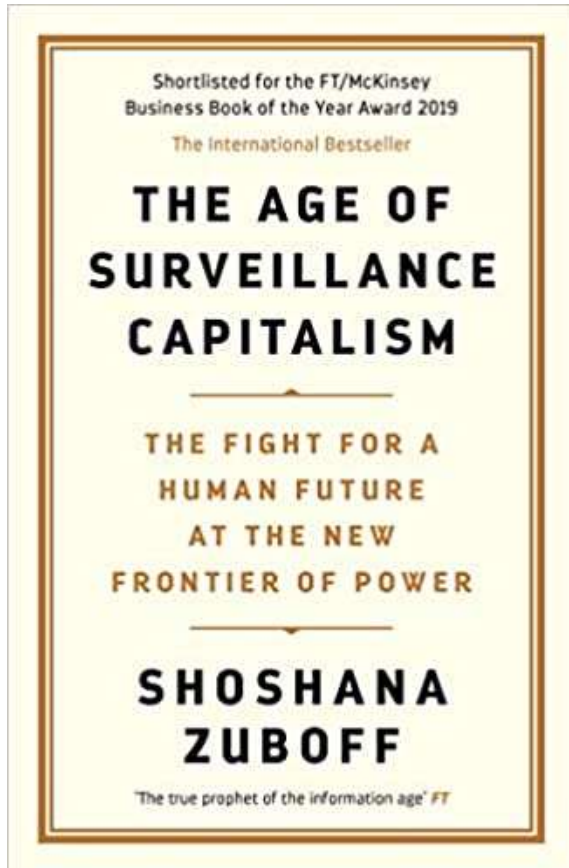
A project of domination of consumers and voters is made possible by artificial intelligence, big data & cognitive psychology



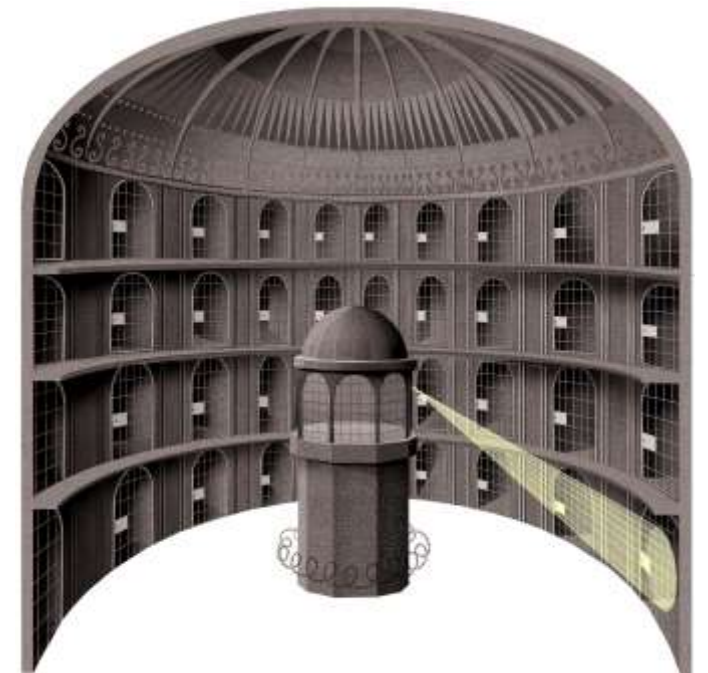
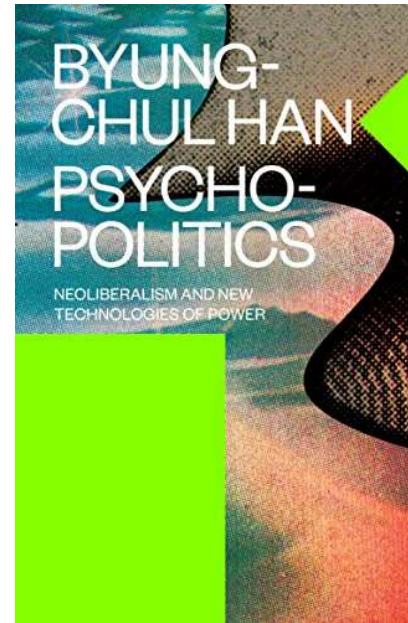
Inequality, power asymmetries and the world of surveillance capitalism

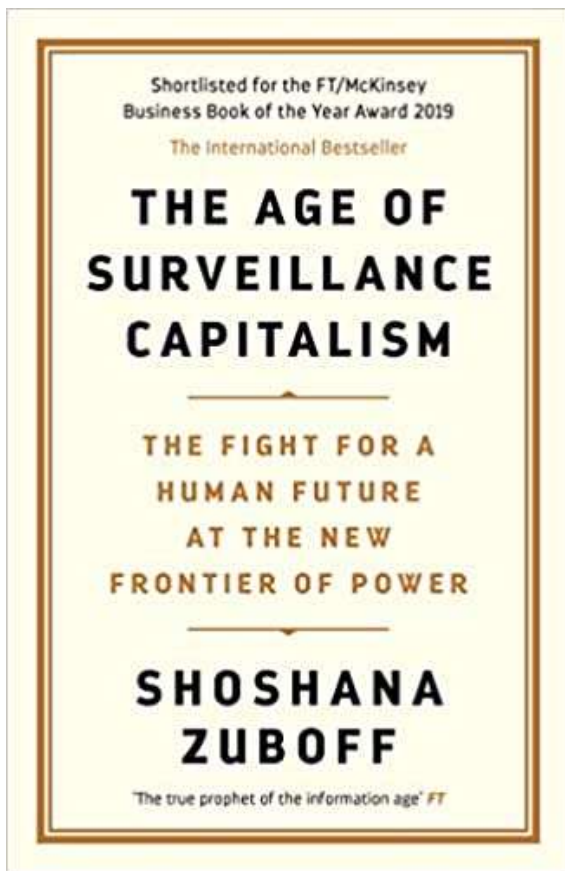


... and the surveillance is voluntarily accepted



Byung Chul Han 'virtual panopticon'





Chapters 11 & 12

Instrumentarian
power



Chapter 10

Néorationalism d'importation

*La trollisation de l'espace
public*

AI empowered with
cognitive psychology

A project of domination?

NYT running the story of one worker working difficult hours

The New York Times

Working Anything but 9 to 5

Scheduling Technology Leaves Low-Income Parents With Hours of Chaos

By **JODI KANTOR**, Photographs by **SAM HODGSON**

AUGUST 13, 2014

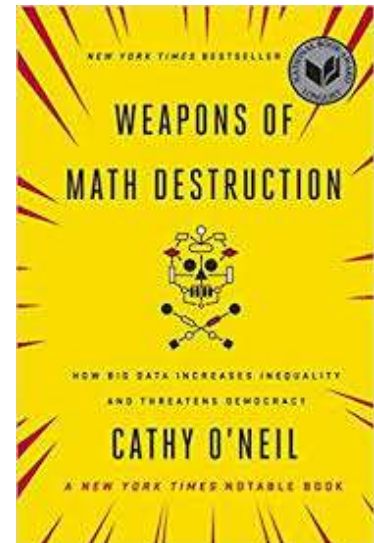


<https://www.nytimes.com/interactive/2014/08/13/us/starbucks-workers-scheduling-hours.html>

“managers’ pay is contingent upon the efficiency of their staff measured by revenue for employee hour” p. 126

“I consider scheduling software one of the more appalling WMD [Weapon of Math Destruction]” p. 128

O’Neil, C. (2016). Weapons of math destruction : how big data increases inequality and threatens democracy. Random House Publishing Group.



The New York Review of Books

The Boss Will See You Now

Zephyr Teachout
August 18, 2022 issue

We are experiencing a major turning point in the surveillance of workers, driven by wearable tech, artificial intelligence, and Covid.

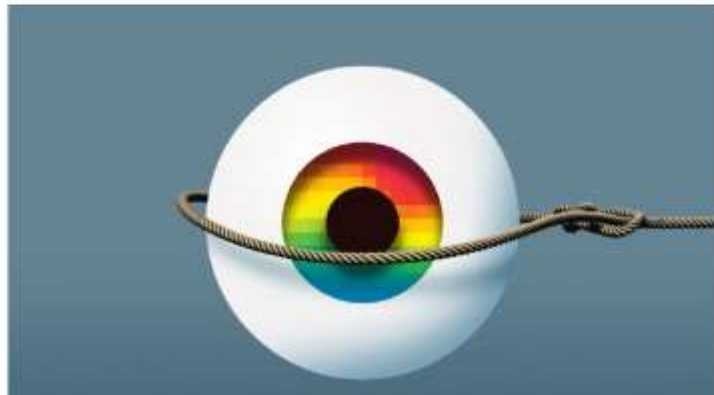


The New York Review of Books

The Coming Tech Autocracy

Sue Halpern
November 7, 2024 issue

A functional government, committed to safeguarding its citizens, might be keen to create a regulatory agency for AI or pass comprehensive legislation, but we in the United States do not have such a government.



The New York Times

Working Anything but 9 to 5

Scheduling Technology Leaves Low-income Parents With 1 hour of 12am

By LISA KAPLAN, Photographs by SAM WELLS
JULY 14, 2024

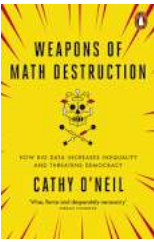
SAN DIEGO — In a typical last-minute scramble, Jessica Hickey, a 20-

Some reading

**The New York Review
of Books**

NETFLIX

Some watching



NETFLIX

UNLIMITED TV SHOWS & MOVIES

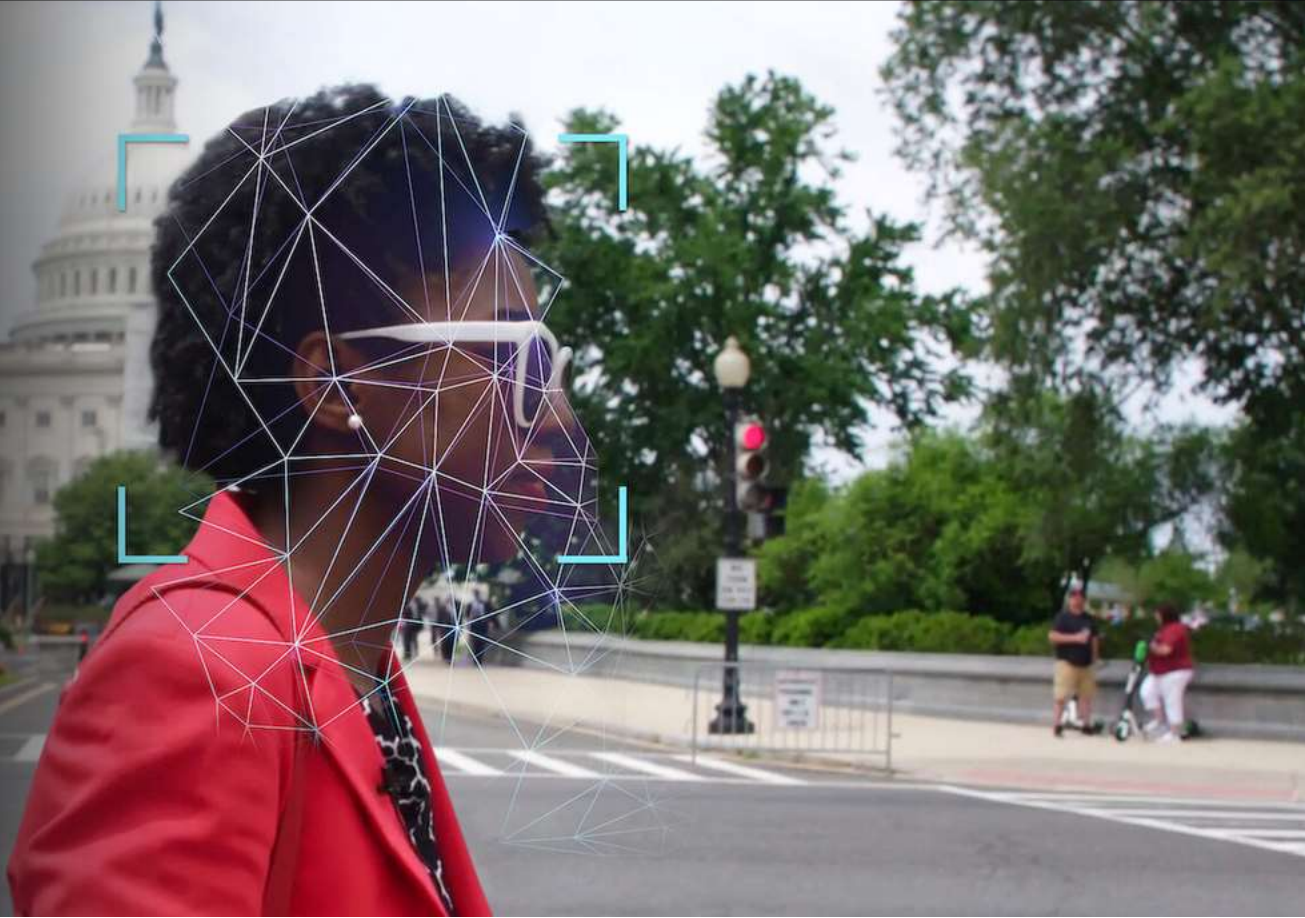
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C O D E D B I A S

Coded Bias

2020 | 12+ | 1h 25m | Science & Nature Docs

This documentary investigates the bias in algorithms after M.I.T. Media Lab researcher Joy Buolamwini uncovered flaws in facial recognition technology.





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**TECHNOLOGY SHOULD
SERVE ALL OF US. NOT JUST
THE PRIVILEGED FEW.**

Join the Algorithmic Justice League in the movement towards equitable and accountable AI.

Enter your email

JOIN THE MOVEMENT



Algorithmic Justice
League

<https://www.ajl.org/>

The New York Times

Bloomberg
Business

Forbes

TIME

FORTUNE

TED

WIRED

The Telegraph

A useful illustration of strategies of capture, starring O'Neil, Zuboff, Lanier, and GAFA technologists...

NETFLIX

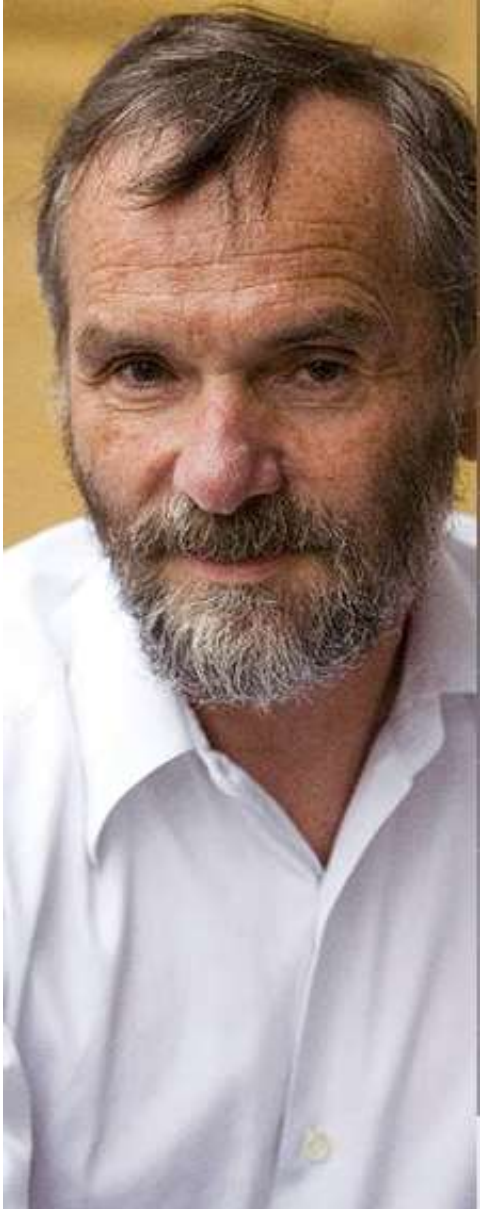
N FILM
/the
social dilemma



... such as Tristan Harris, former design ethicist at Google, explaining from inside how social media pursue addiction to maximize profit and manipulates people's behaviour



Alain Supiot

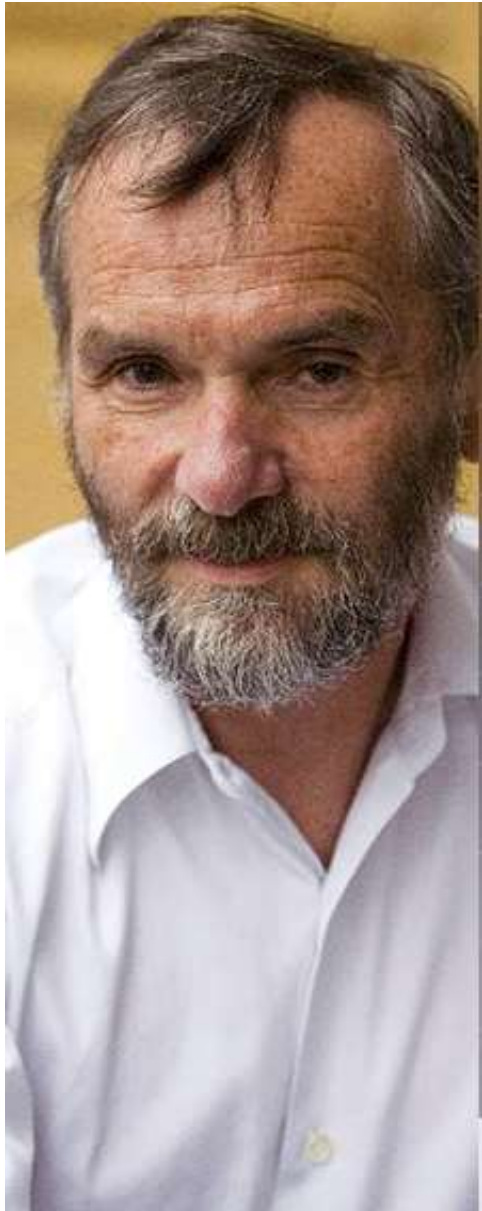


An indictment of the Total Market and the normative uses of economic quantification

<https://www.college-de-france.fr/site/en-alain-supiot/Governance-by-Numbers-Introduction.htm>



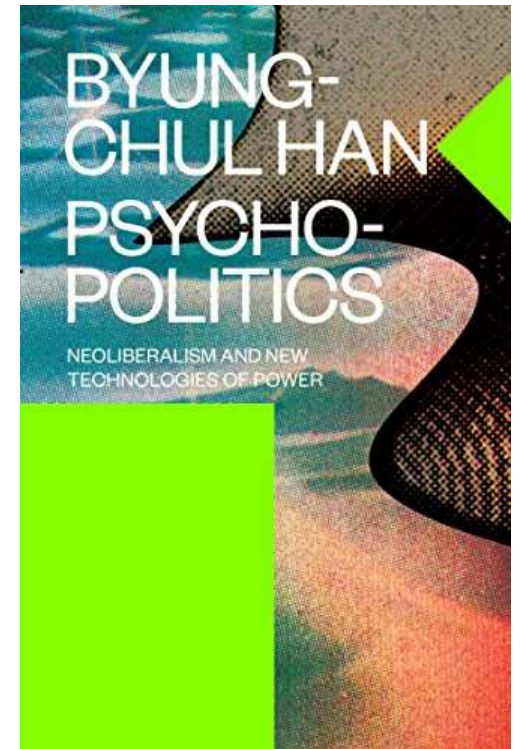
Alain Supiot

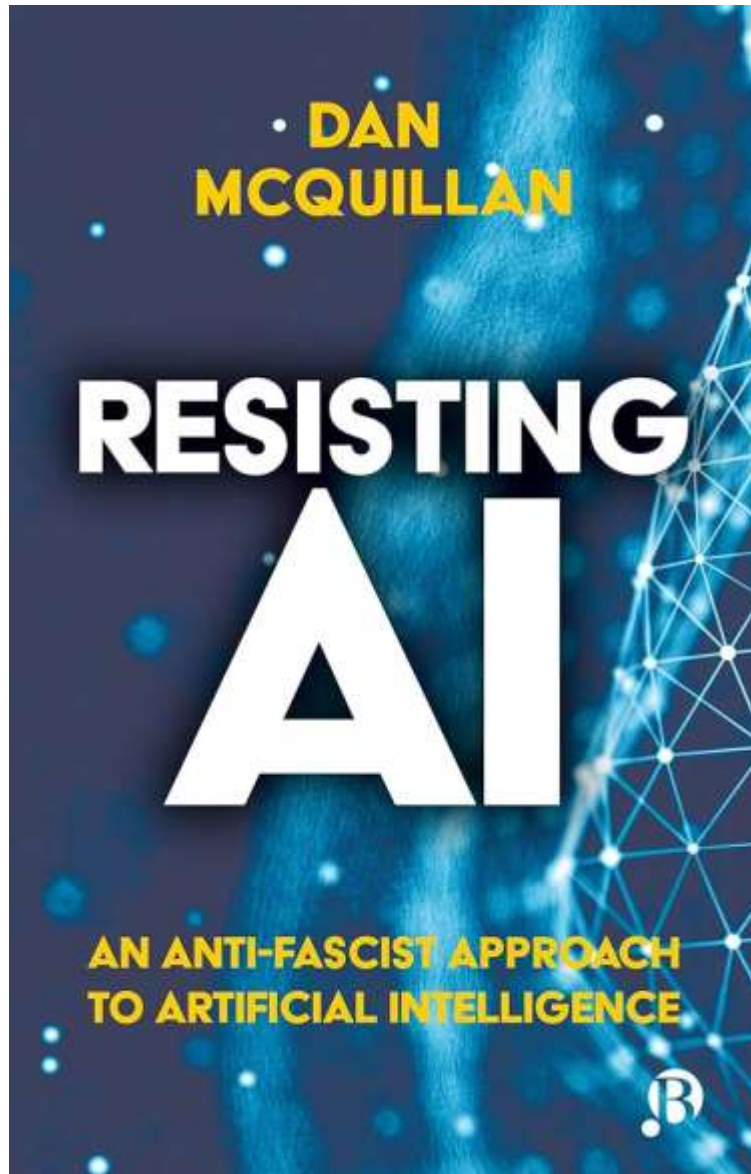


...we have entered the era of the cybernetic imaginary, which revives the West's age-old dream of grounding social harmony in calculations.

Same diagnosis about the neoliberal 'exploitation of freedom' from Byung Chul Han

Slave of ourselves





Resisting AI contrasts optimistic visions about AI's ... AI may best be seen as a continuation and reinforcement of bureaucratic forms of discrimination and violence, ultimately fostering authoritarian outcomes

AI's promise of objective calculability is antithetical to an egalitarian and just society

... Based on opaque algorithms – various actors can discriminate against categories of people in accessing jobs, loans, medical care, and other benefits

Dangers of mathematization of economics



Wolfgang Drechsler



Erik S. Reinert



Paul Romer



Philip Mirowski

W. Drechsler, "On the possibility of quantitative-mathematical social science, chiefly economics," *J. Econ. Stud.*, vol. 27, no. 4/5, pp. 246–259, 2000.

E. S. Reinert, "Full circle: economics from scholasticism through innovation and back into mathematical scholasticism," *J. Econ. Stud.*, vol. 27, no. 4/5, pp. 364–376, Aug. 2000.

P. Romer, "Mathiness in the Theory of Economic Growth," *Am. Econ. Rev.*, vol. 105, no. 5, pp. 89–93, May 2015.

Mirowski, Philip. 2013. *Never Let a Serious Crisis Go to Waste: How Neoliberalism Survived the Financial Meltdown*. Verso.



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WORKING PAPER
WP 2021/07

Altered States: Cartesian and Ricardian dreams

Erik S. Reinert

Tallinn University of Technology

UCL Institute for Innovation and Public Purpose

Monica di Fiore

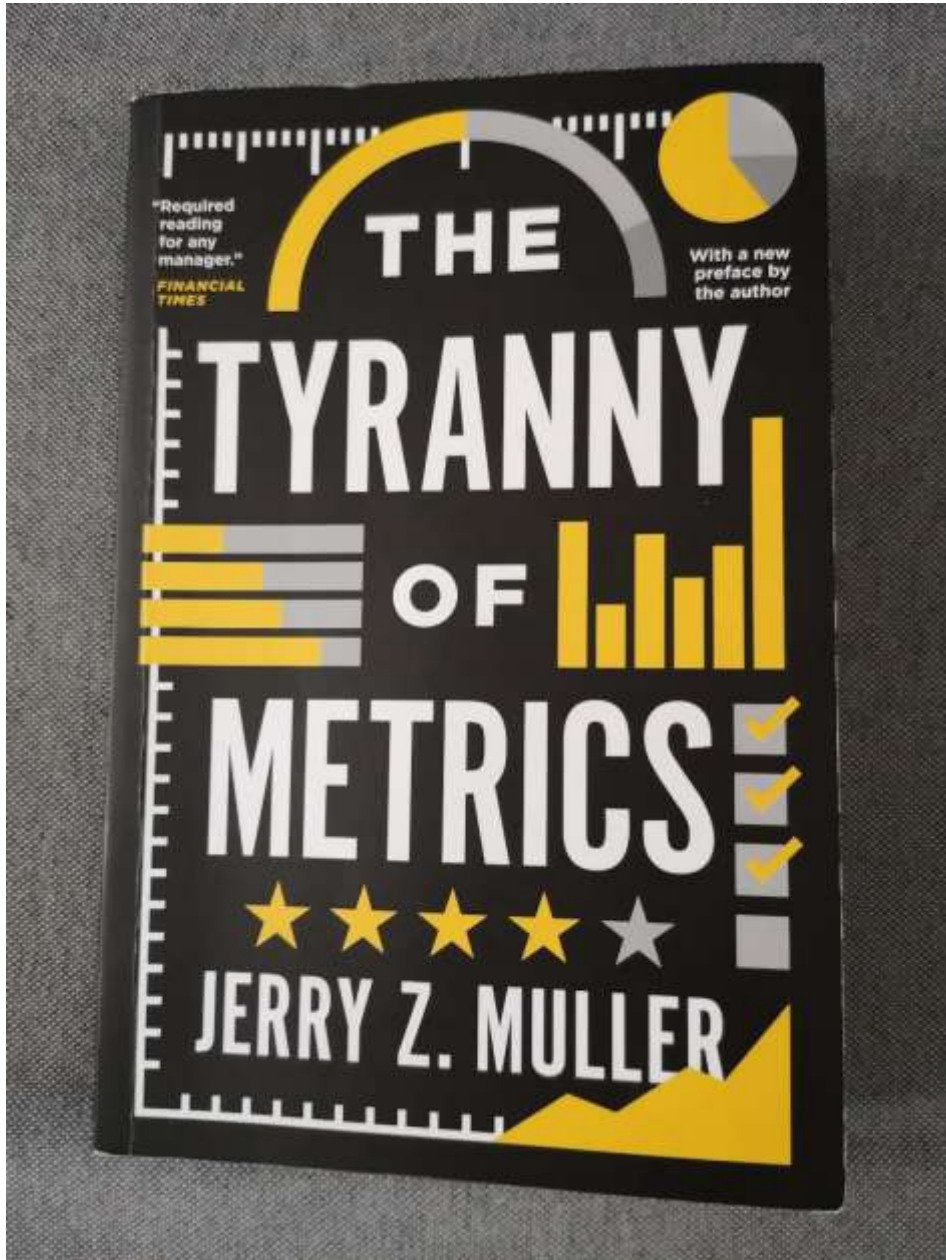
Institute for Cognitive Sciences and Technologies, Consiglio Nazionale delle Ricerche

Andrea Saltelli

Open Evidence Research, Universitat Oberta de Catalunya (UOC)

Jerome R. Ravetz

Institute for Science, Innovation and Society, University of Oxford

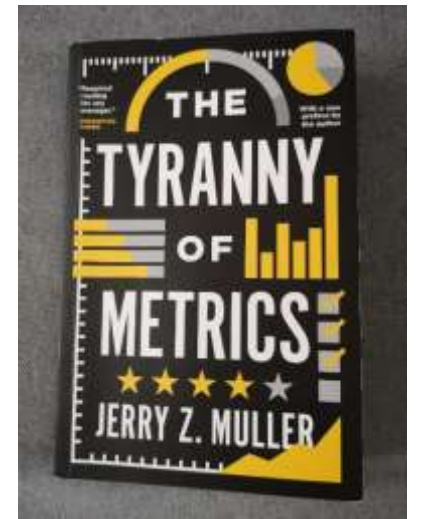


J. Z. Muller, *The tyranny of metrics*. Princeton University Press , 2018.

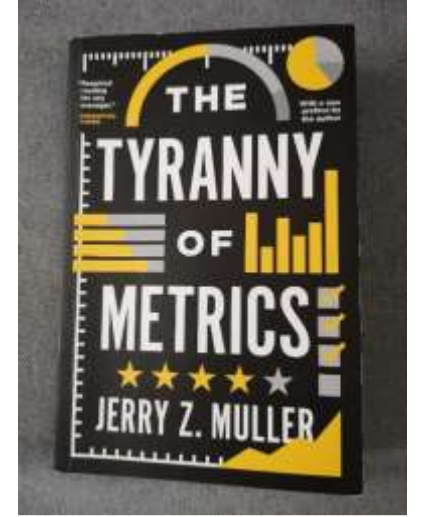
Metric fixation, or the irresistible pressure to measure performance

Gaming of metrics (recall Goodhart law)

A wealth of case studies from education to war to medicine to foreign aid..



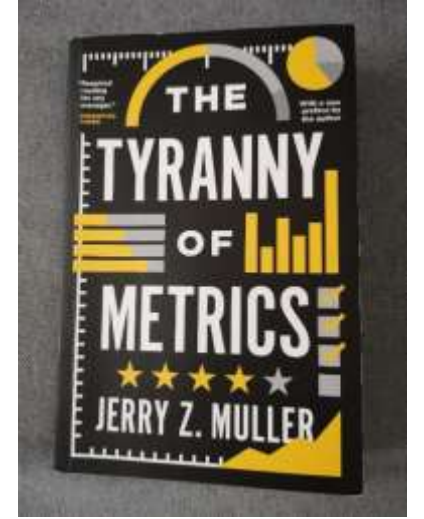
Unintended consequences



- Goal displacement
- Short termism
- Diminishing utility
- Rule cascade
- Discouraging risk taking
- Discouraging innovation
- Rewarding luck
- Discouraging cooperation and common purpose
- Degrading work
- Time waste
- Loss of productivity

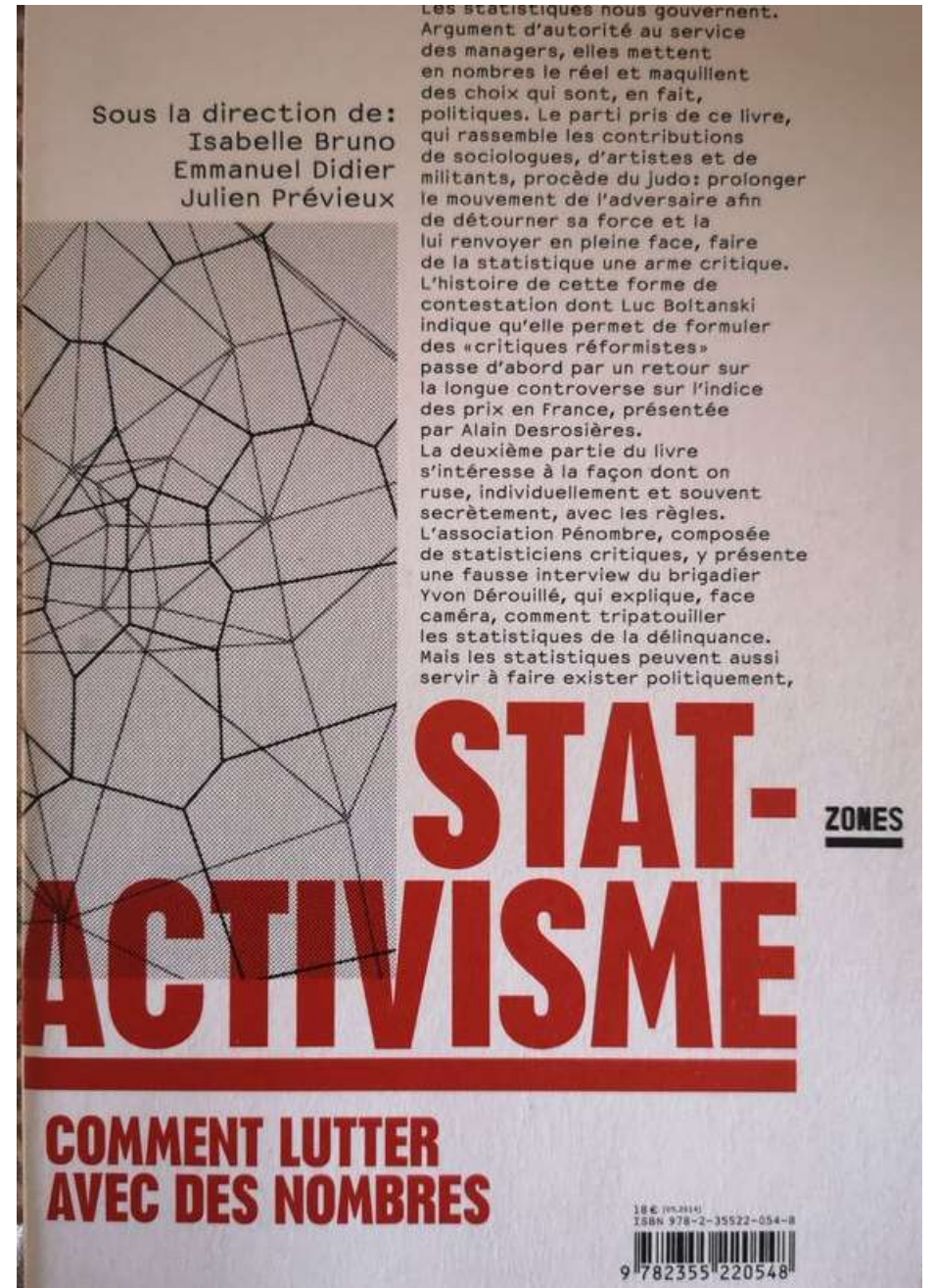
A concluding remark of Muller

Considering all of the above keep in mind at every step that “the best use of metrics **may** be not to use it at all”



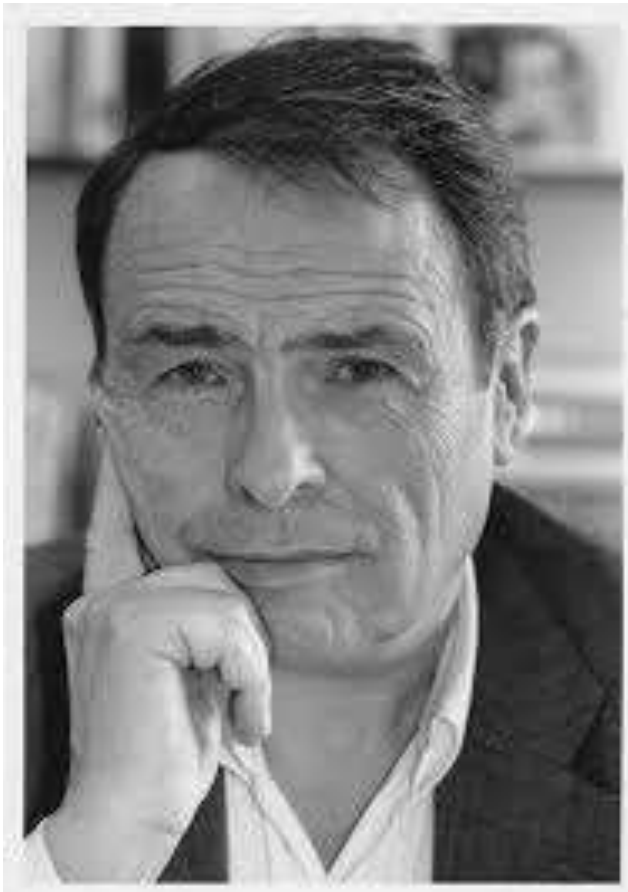
Do we need a movement of resistance?

I. Bruno, E. Didier, and J. Prévieux, Stat-activisme. Comment lutter avec des nombres. Paris: Zones, La Découverte, 2014



How to be a "statactiviste"?

1. Deconstruct existing metrics, including using irony (Pierre Bourdieu, *Les héritiers*).



La sociologie,
ça doit être
rigolo

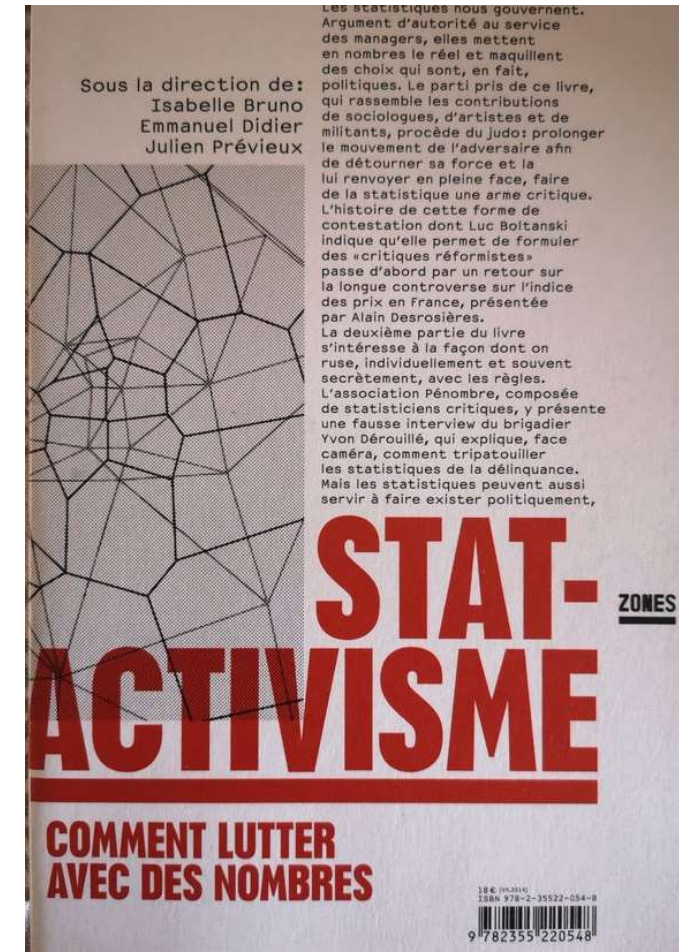
(Sociology must be fun)



How to be a "statactiviste"?

2. Gaming metrics (statistical judo) – use Goodhart's law to your advantage – or make the ruse public.

- Police statistics in NY



How to be a "statactiviste"?

3. Bring to the surface what is hidden / unsaid/ excluded – new social classes, marginalization, minorities:

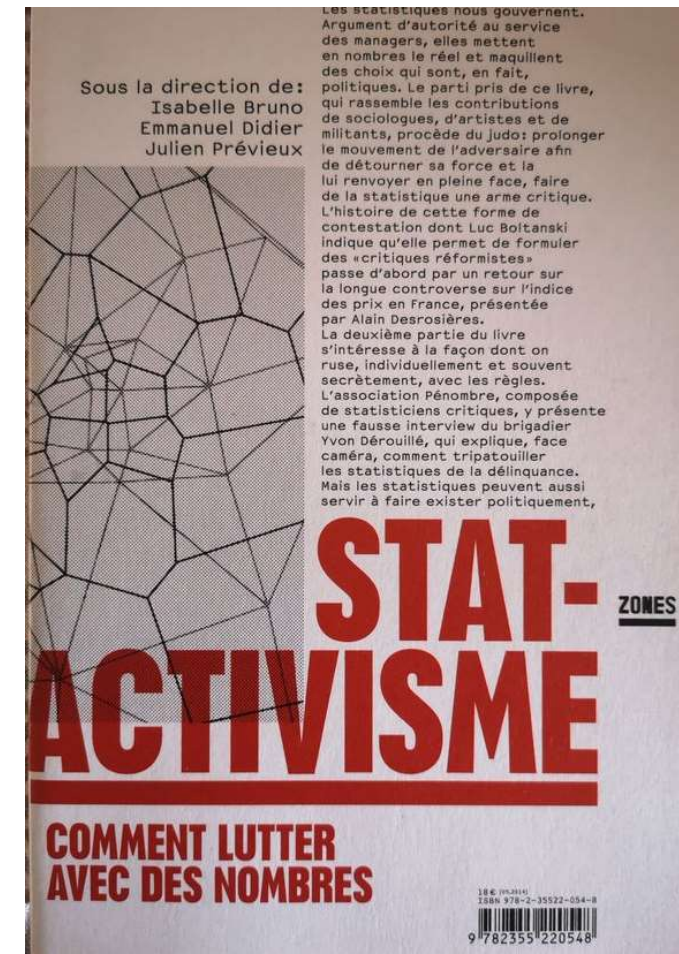
- ‘Creative class’ or ‘precarious intellectuals’?



How to be a "statactiviste"?

4. Measure something different.

- Suicides at France Telecom;
- BIP 40, a new French measure of poverty/inequality



Important:

“Quantification should not be abandoned to the advantage of exalting qualities, singularities, and the incommensurable. Such an abandon would be a tactical error”

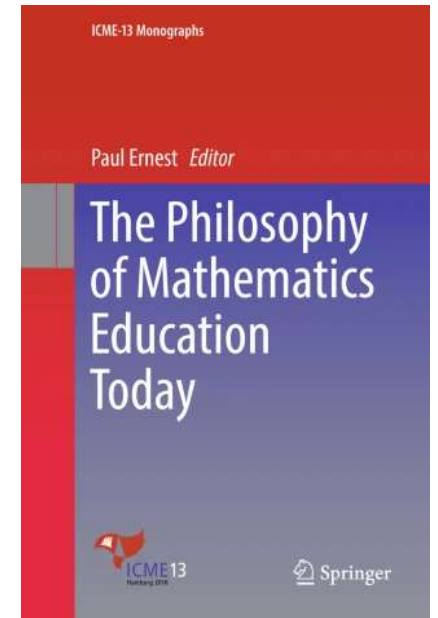




The Ethics of Mathematics: Is Mathematics Harmful?

Paul Ernest

© Springer International Publishing AG, part of Springer Nature 2018
P. Ernest (ed.), *The Philosophy of Mathematics Education Today*,
ICME-13 Monographs, https://doi.org/10.1007/978-3-319-77760-3_12



Mathematics – styles of thinking that can be damaging when applied beyond mathematics to social and human issues

Condorcet's dream

Applications in society can be deleterious to our humanity unless very carefully monitored and checked

Algorithms

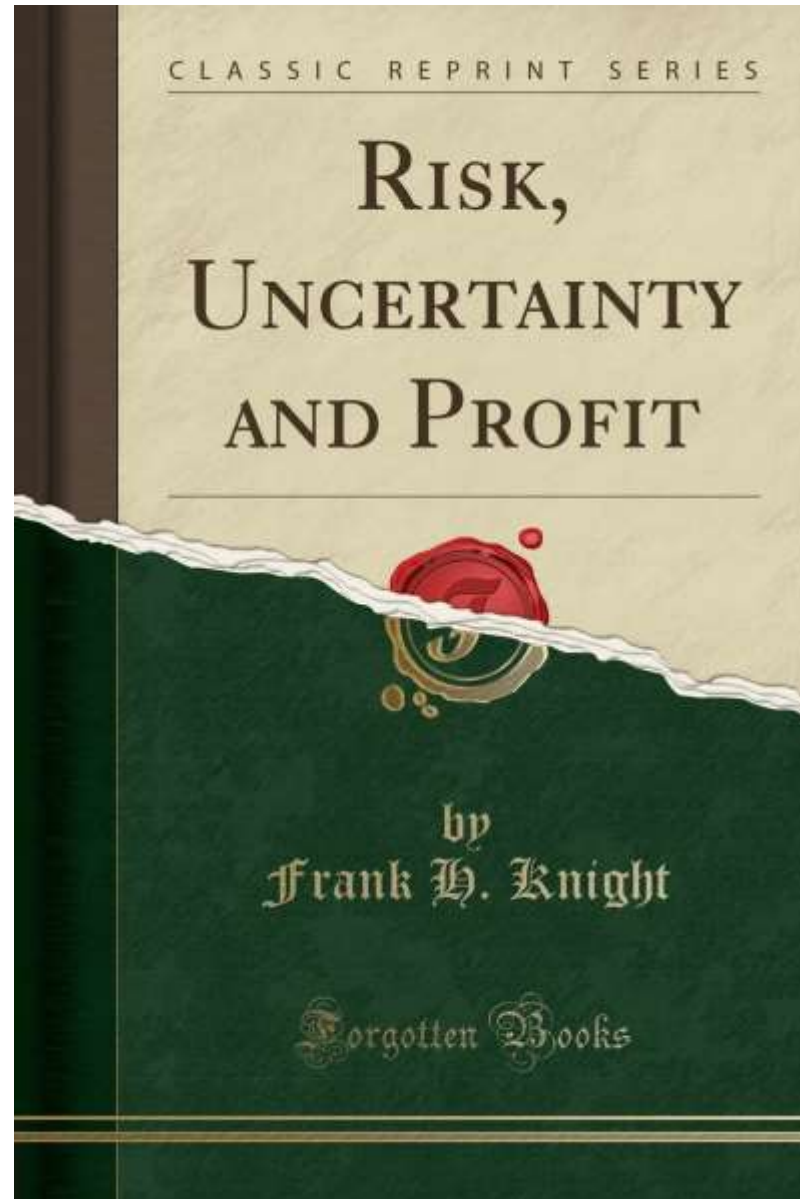
Impact of learning mathematics on learners' thinking and life chances

Regimenting, stigmatizing

Frank Knight (1921) distinguished risk from uncertainty

Risk = know outcomes & probabilities;
roulette game

Uncertainty = unsure about the probabilities;
starting a business



Frank H. Knight
1885-1972

But the story has many more twists

The debate between Leonard Savage and Frank Ramsey on one side and John Maynard Keynes and Frank Knight on the other: **a fundamental disagreements in decision theory**

Savage and Ramsey: pioneers of subjective probability theory for rational decision making –
Keynes and Knight: sceptical that all uncertainties could be quantified probabilistically due to uncertainty & ambiguities



Leonard Jimmie
Savage
(1917–1971)



Frank Ramsey
(1903–1930)

But the story has many more twists ... Suggested reading

Savage's agents are rational and indifferent to ambiguity. Keynes and Knight suggested that known risks are preferred over unknown ones → today behavioural economics

Savage and Ramsey “won” but see “info-gap theory” and “robust decision-making” (both involving better exploration and sensitivity analysis)



Frank H. Knight
1885–1972



John Maynard Keynes
1883–1946

FINANCIAL TIMES

US COMPANIES TECH MARKETS CLIMATE OPINION LEX WORK & CAREERS LIFE & ARTS HTSI

Opinion **Financial Times**

The other multiplier effect, or Keynes's view of probability

For the economist, probability was about believability, not frequency

JOHN KAY [+ Add to myFT](#)

Mathematical and statistical models

nature communications

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Comment | [Open Access](#) | [Published: 27 August 2019](#)

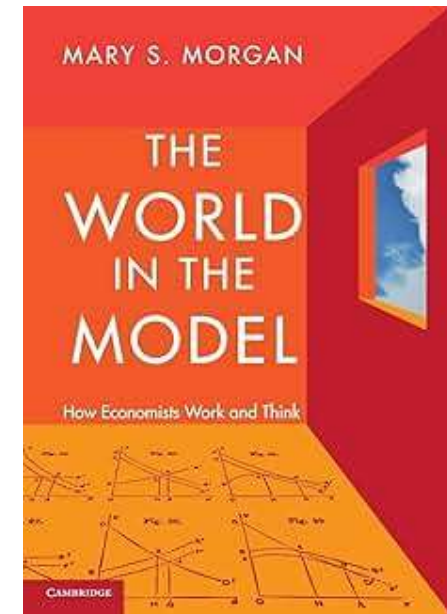
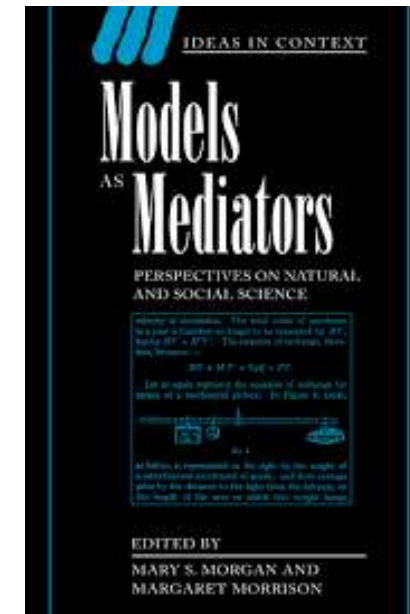
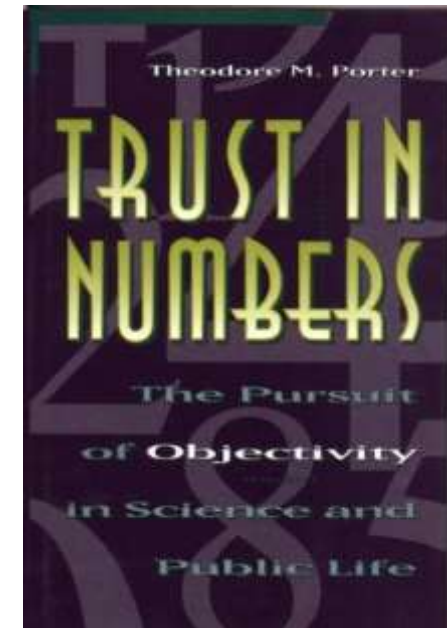
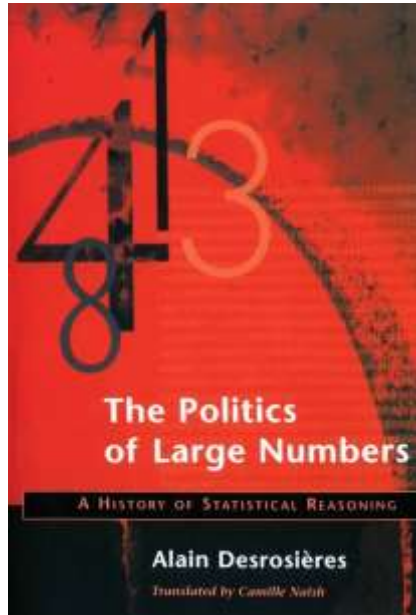
A short comment on statistical versus mathematical modelling

[Andrea Saltelli](#) 

[Nature Communications](#) **10**, Article number: 3870 (2019) | [Cite this article](#)

Mathematical models escape sociology of quantification

Statistics has a much deeper connection to sociology, and to sociology of quantification in particular (Desrosières, 1998; Mennicken & Espeland, 2019; Mennicken & Salais, 2022) than mathematical modelling. Sociology of quantification treats impact assessment tools such as cost benefit analysis (Porter, 1995). Less on modelling, see exceptions: (Morgan, 2012, Morgan & Morrison, 1999).



Five ways to ensure that models serve society: a manifesto

Pandemic politics highlight how predictions need to be transparent and humble to invite insight, not blame.

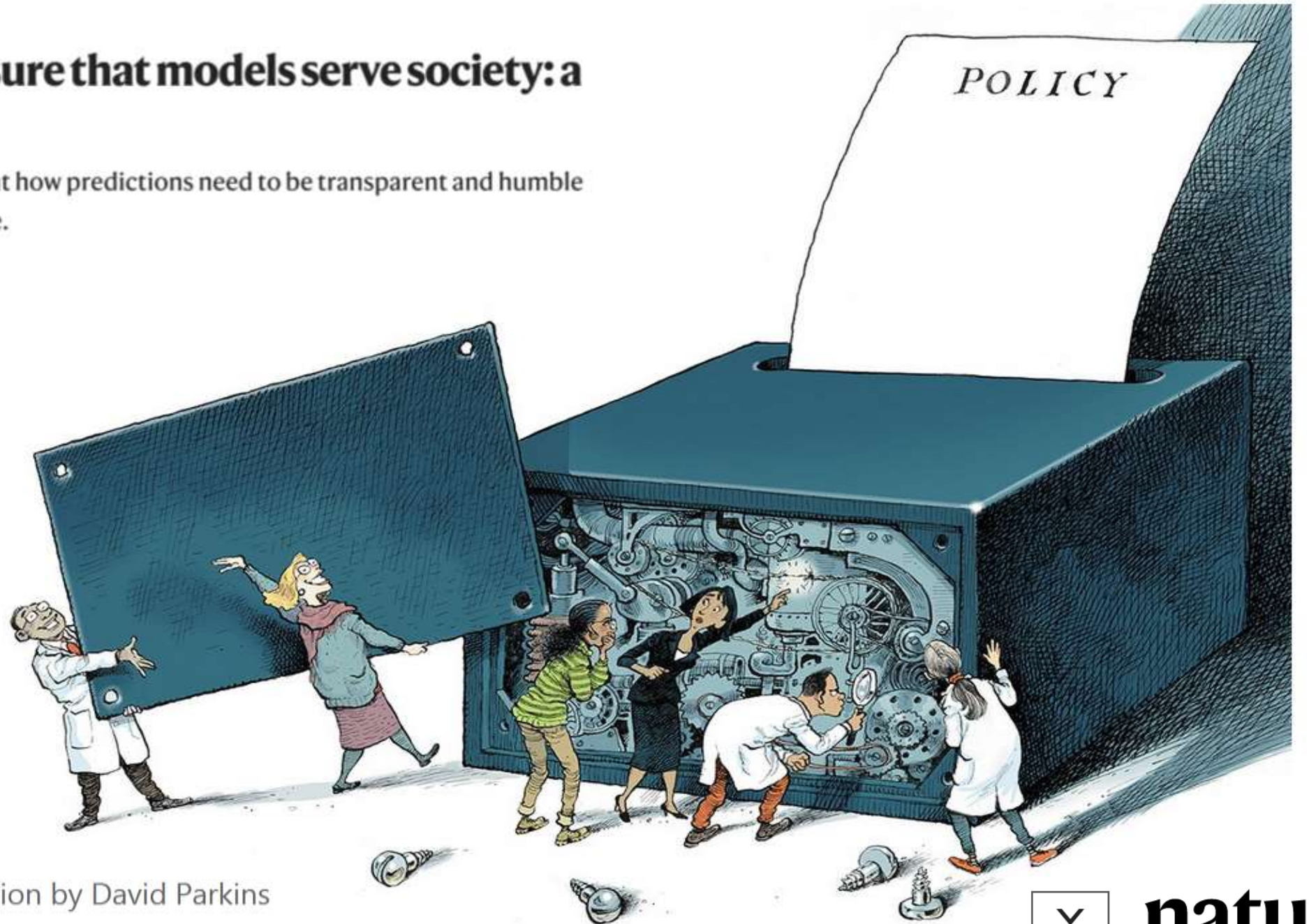


Illustration by David Parkins



nature

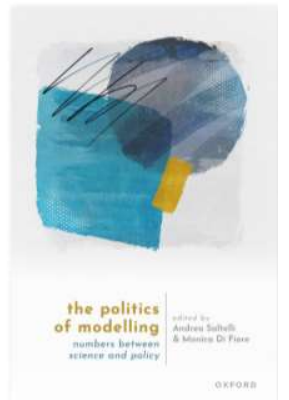
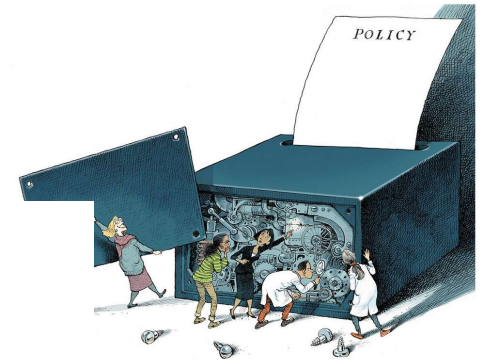
Power

The New York Times

Behind the Virus Report That Jarred the U.S. and the U.K. to Action

It wasn't so much the numbers themselves, frightening though they were, as who reported them: Imperial College London.

Landler, Mark, and Stephen Castle. 2020. Behind the Virus Report That Jarred the U.S. and the U.K. to Action – The New York Times.



Conflicts, when questions of urgency, stakes, values and uncertainty collide

Rush Limbaugh

“Wild-Ass Covid numbers
... The minute I hear
anybody start talking about
models and modeling, I
blanch”



Rhodes, Tim, and Kari Lancaster. 2020. “Mathematical Models as Public Troubles in COVID-19 Infection Control: Following the Numbers”, *Health Sociology Review* 1-18. doi: 10.1080/14461242.2020.1764376

Mind the assumptions

Assess uncertainty and sensitivity



Mind the hubris

Complexity can be the enemy of relevance

Mind the framing

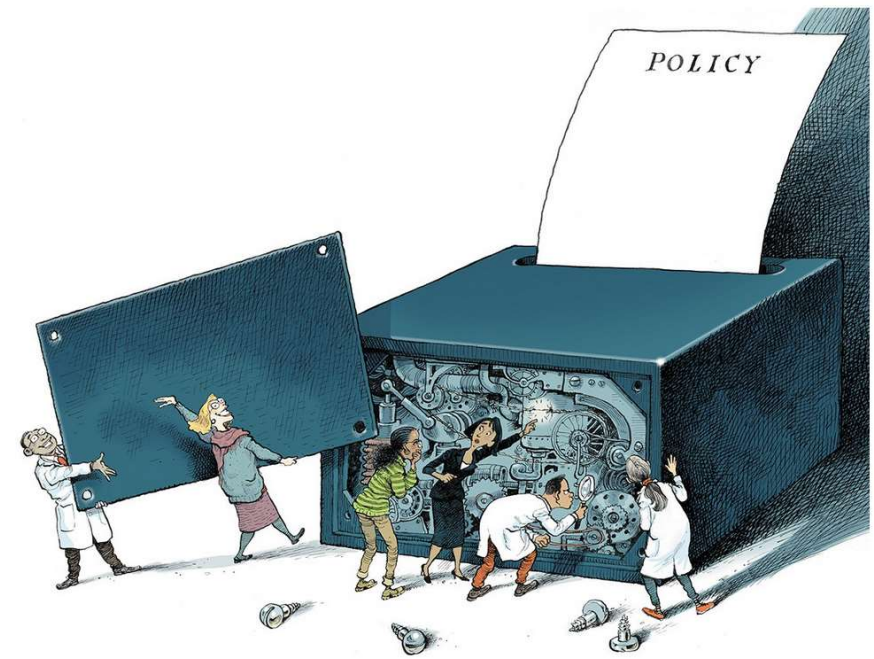
Match purpose and context

Mind the consequences

Quantification can backfire.

Mind the unknowns

Acknowledge ignorance



Mind the assumptions

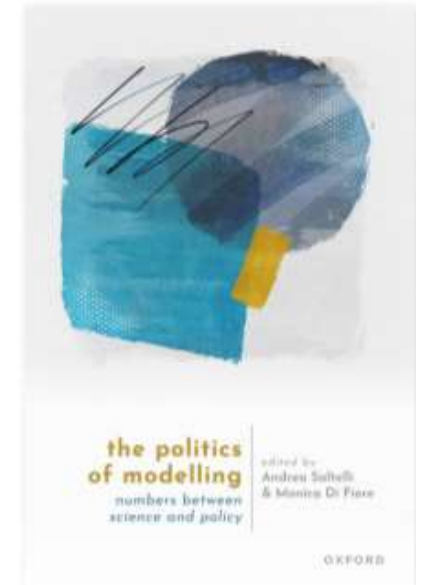
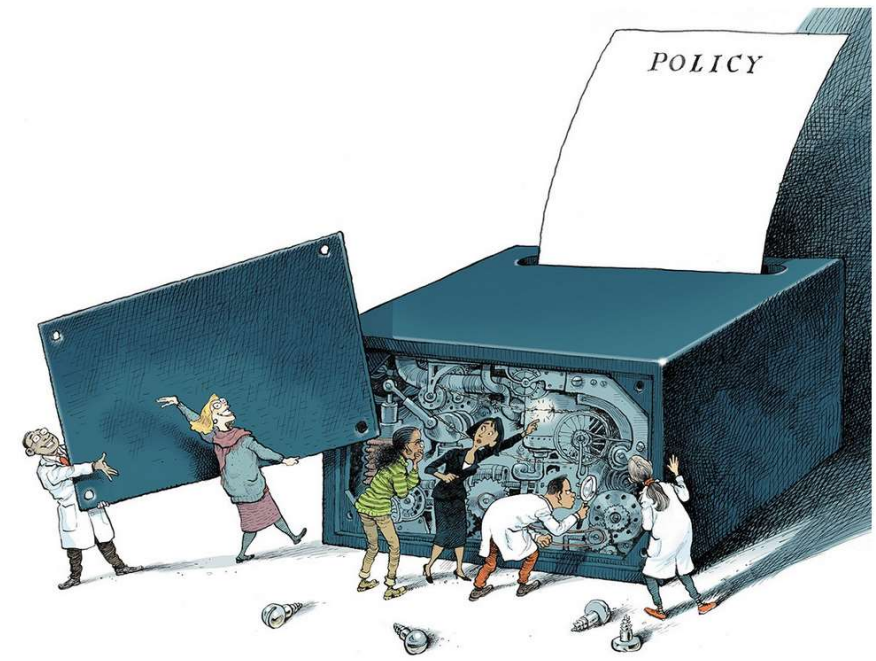
Assess uncertainty and sensitivity



... models require input values for which there is no reliable information...

... global uncertainty and sensitivity analyses are often not done. Anyone turning to a model for insight should demand them

...

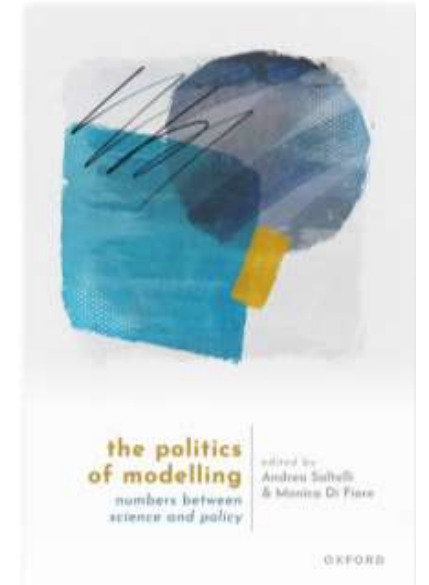
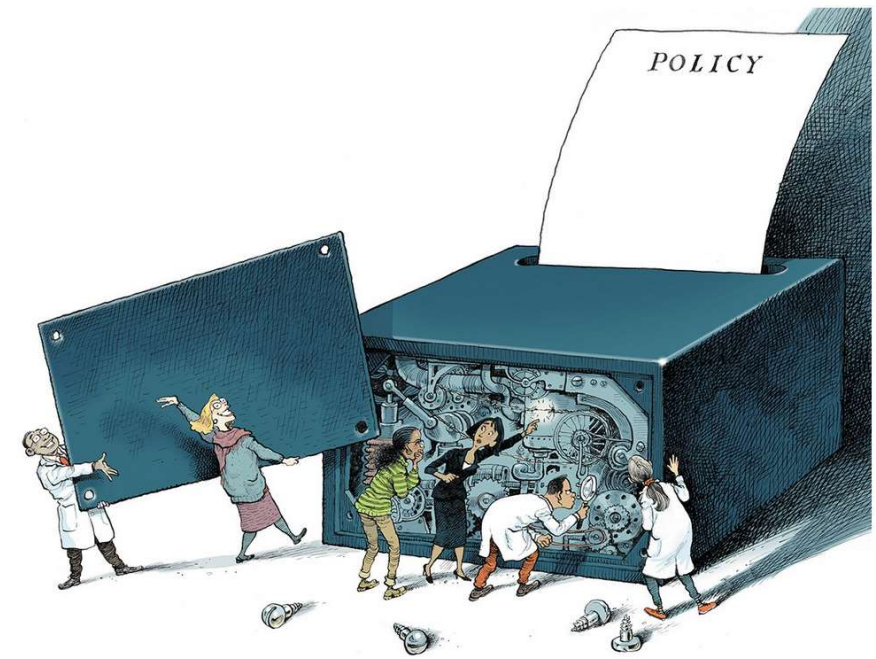


Mind the assumptions

Assess uncertainty and sensitivity



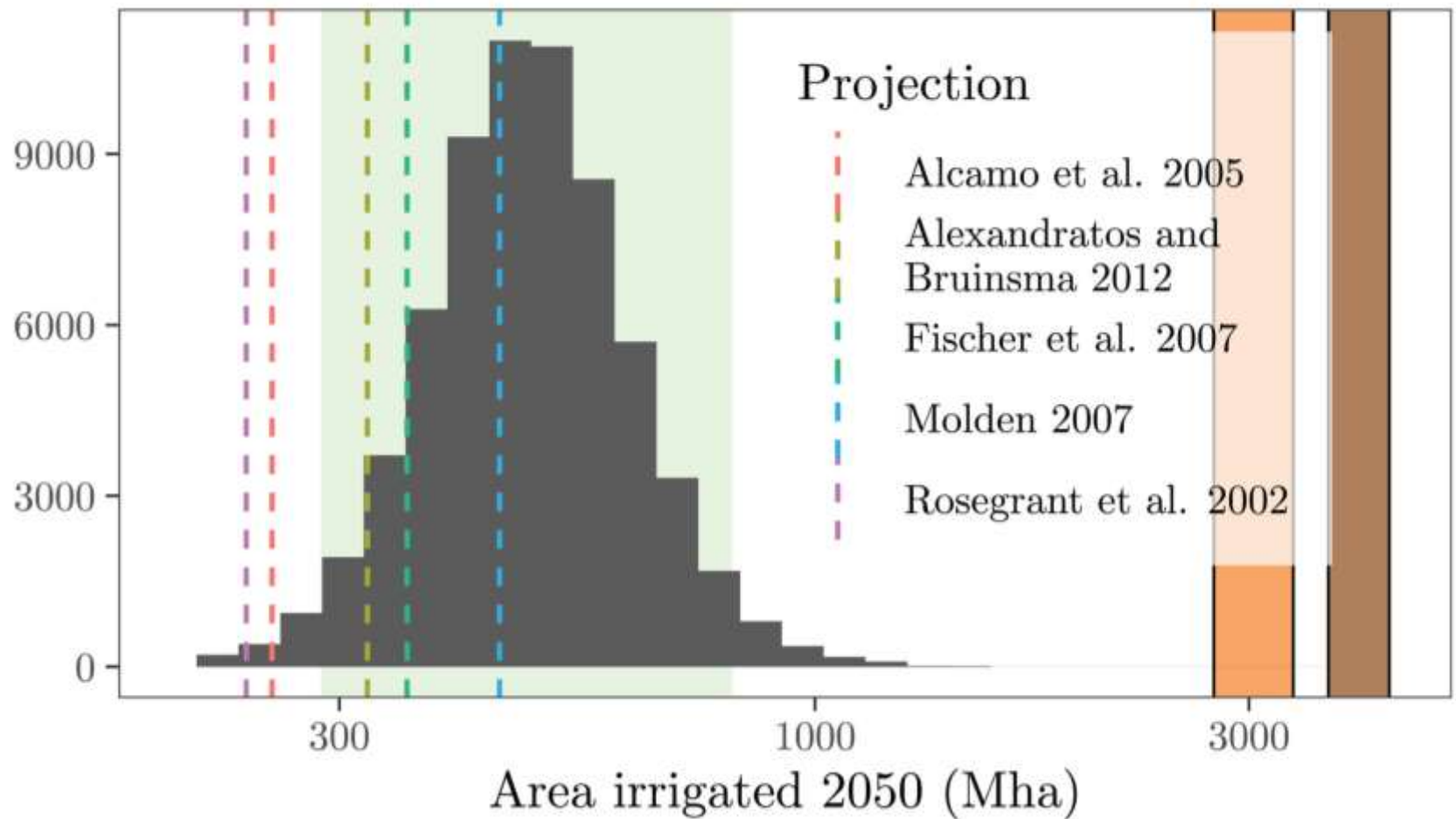
... this may lead to interesting discoveries ...



Geophysical Research Letters

Current Models Underestimate Future Irrigated Areas

A. Puy✉, S. Lo Piano, A. Saltelli First published: 17 April 2020 <https://doi.org/10.1029/2020GL087360> |



Mind the assumptions

Assess uncertainty and sensitivity

Mind the hubris



Complexity can be the enemy of relevance

Mind the framing

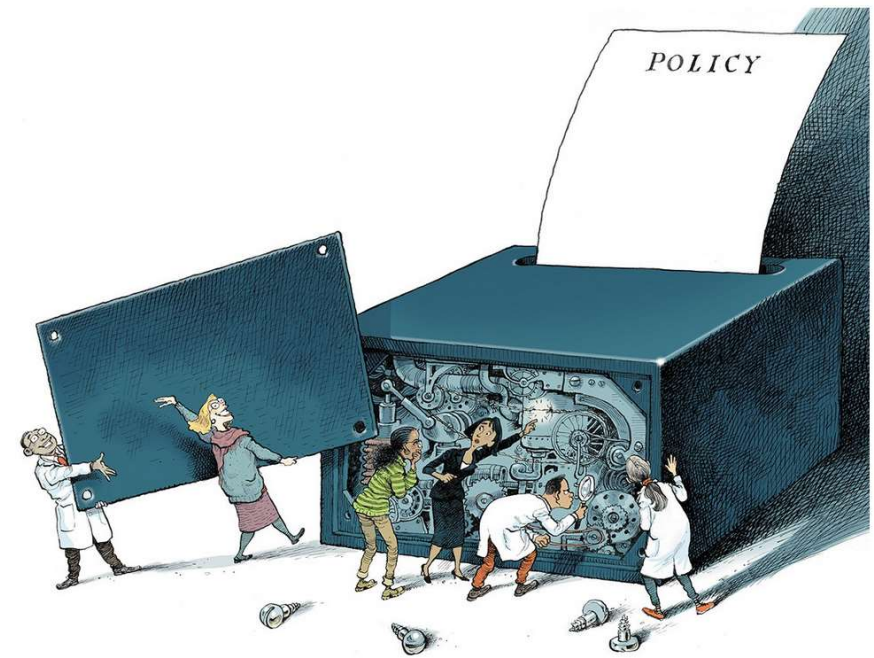
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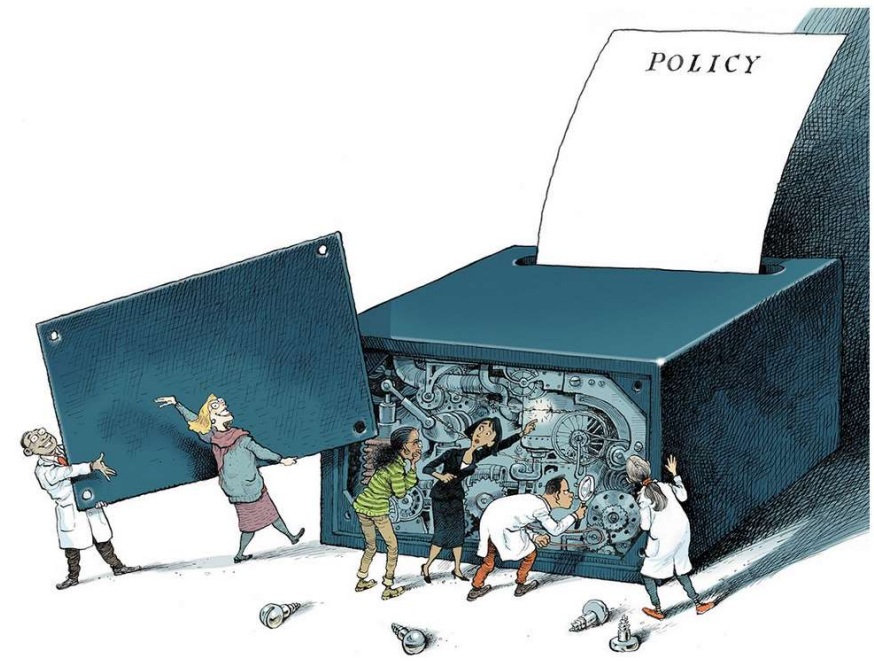
Mind the unknowns

Acknowledge ignorance



Mind the hubris

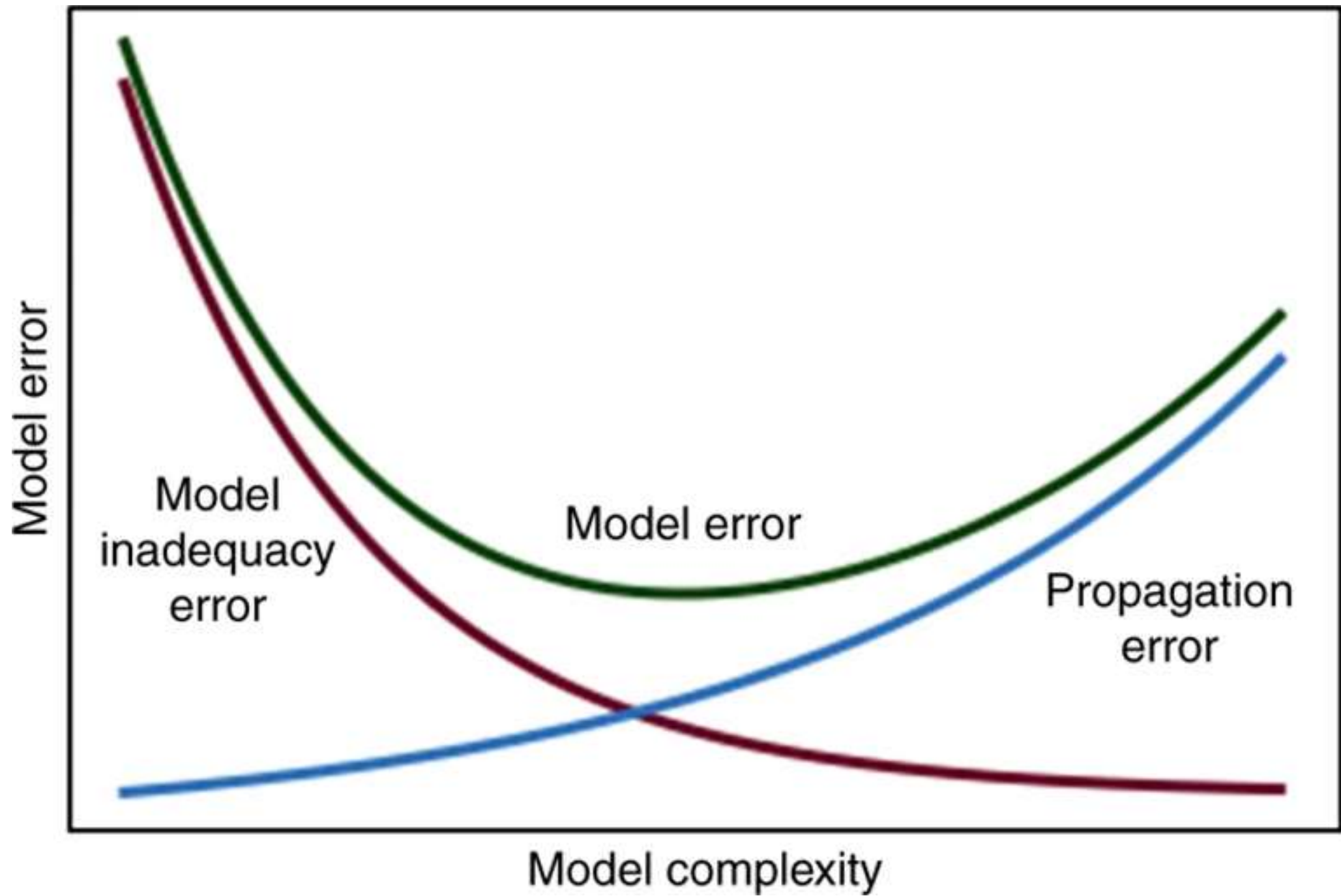
Complexity can be the enemy of relevance



… many are seduced by the idea of adding complexity in an attempt to capture reality more accurately, but…

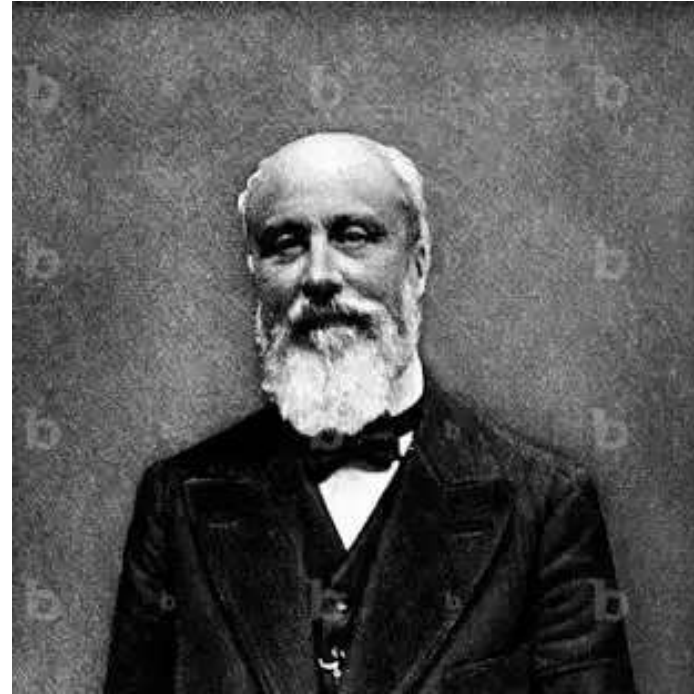
SUPPLEMENTARY INFORMATION

1. [Additional information and references](#) >260 references



“... inferences from mathematical models of phenomena to real physical applications must also be demonstrated to be approximately correct when the assumptions of the model are only approximately true” [1]

Pierre Duhem (1861–1916) and his ‘Principle of stability’



[1] S. C. Fletcher, ‘The Principle of Stability’, *Philosopher’s Imprint*, vol. 20, no. 3, 2020, Accessed: Sep. 08, 2024. [Online].

Models are fragile

Duhem's principle of stability [1], and the occurrence of either Butterfly [2] or Hawkmoth effects [3].

The accumulation of parametric error in a model, the so called uncertainty cascade [4], that is the subject of global sensitivity analysis studies [5].

- [1] S. C. Fletcher, 'The Principle of Stability', *Philosopher's Imprint*, vol. 20, no. 3, 2020, Accessed: Sep. 08, 2024. [Online].
- [2] H. G. Schuster, *Deterministic Chaos: An Introduction*, 2nd Rev edition. Weinheim: Vch Pub, 1998.
- [3] E. Winsberg, 'Appendix: Structural Stability and the "Hawkmoth Effect"', in *Philosophy and Climate Science*, Cambridge: Cambridge University Press, 2018, pp. 232–246. doi: 10.1017/9781108164290.016.
- [4] M. Christie, A. Cliffe, P. Dawid, and S. S. Senn, *Simplicity, Complexity and Modelling*. Wiley, 2011.
- [5] A. Saltelli et al., 'Five ways to ensure that models serve society: a manifesto', *Nature*, vol. 582, pp. 482–484, 2020.

“I have proposed a form of **organised sensitivity analysis** that I call **‘global sensitivity analysis’** in which a neighborhood of alternative assumptions is selected and the corresponding interval of inferences is identified.

Conclusions are judged to be sturdy only if the neighborhood of assumptions is wide enough to be credible and the corresponding interval of inferences is narrow enough to be useful.”

Edward E. Leamer, 1990, Let's Take the Con Out of Econometrics, *American Economics Review*, 73 (March 1983), 31-43.





HOME > SCIENCE ADVANCES > VOL. 8, NO. 42 > MODELS WITH HIGHER EFFECTIVE DIMENSIONS TEND TO PRODUCE MORE UNCERTAIN ESTIMATES

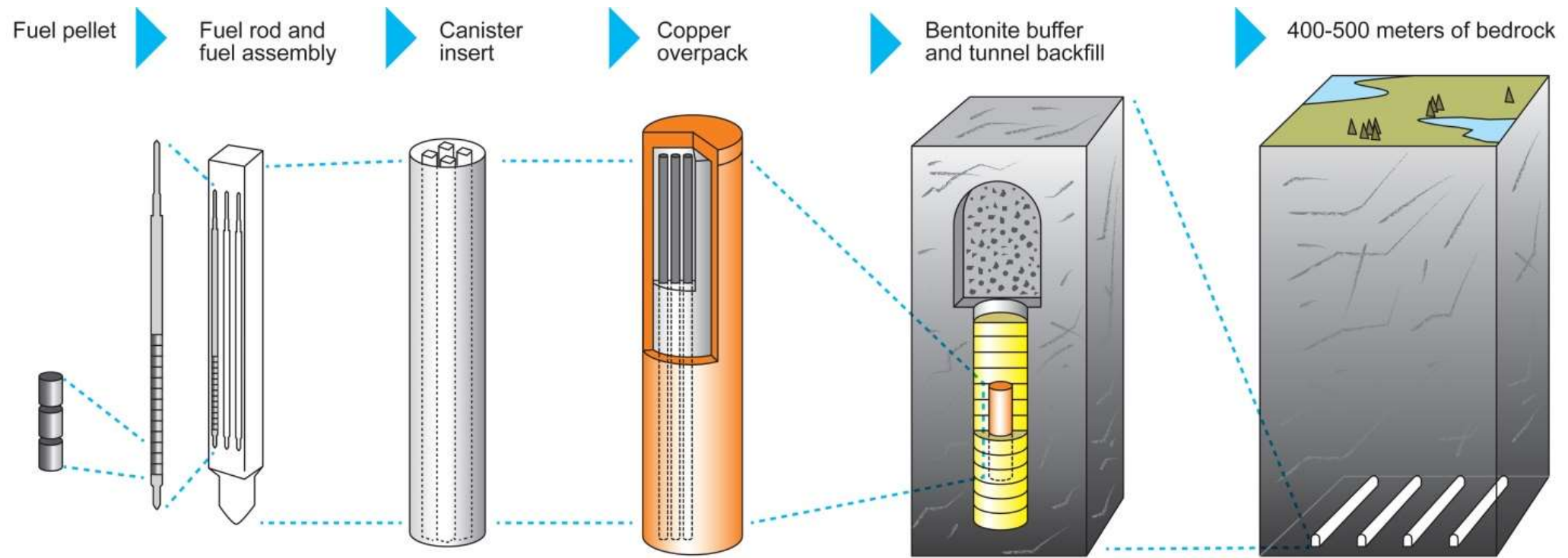
 | RESEARCH ARTICLE | MATHEMATICS



Models with higher effective dimensions tend to produce more uncertain estimates

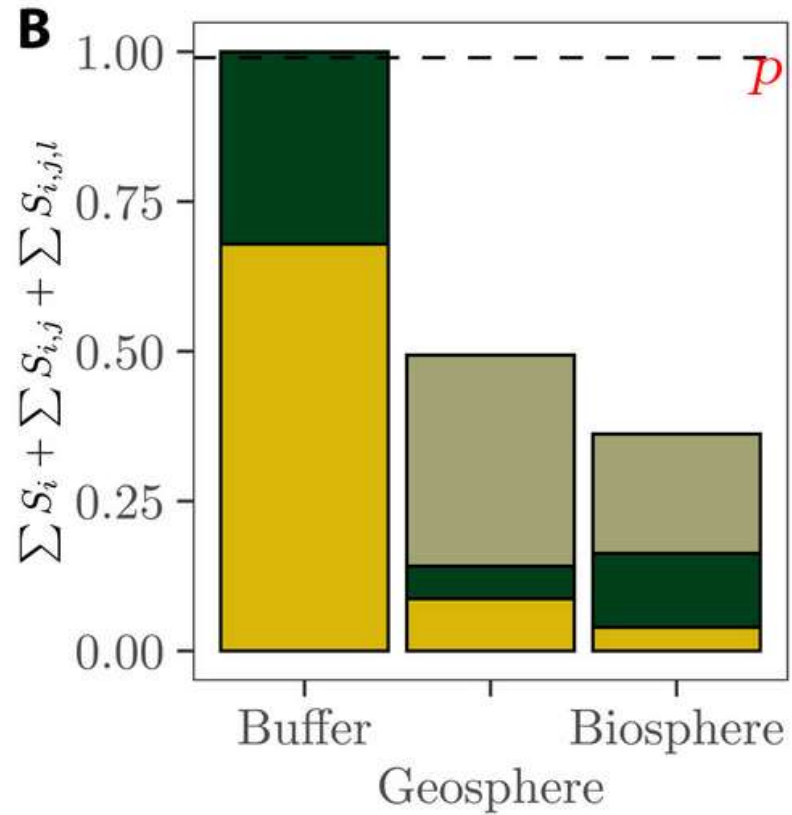
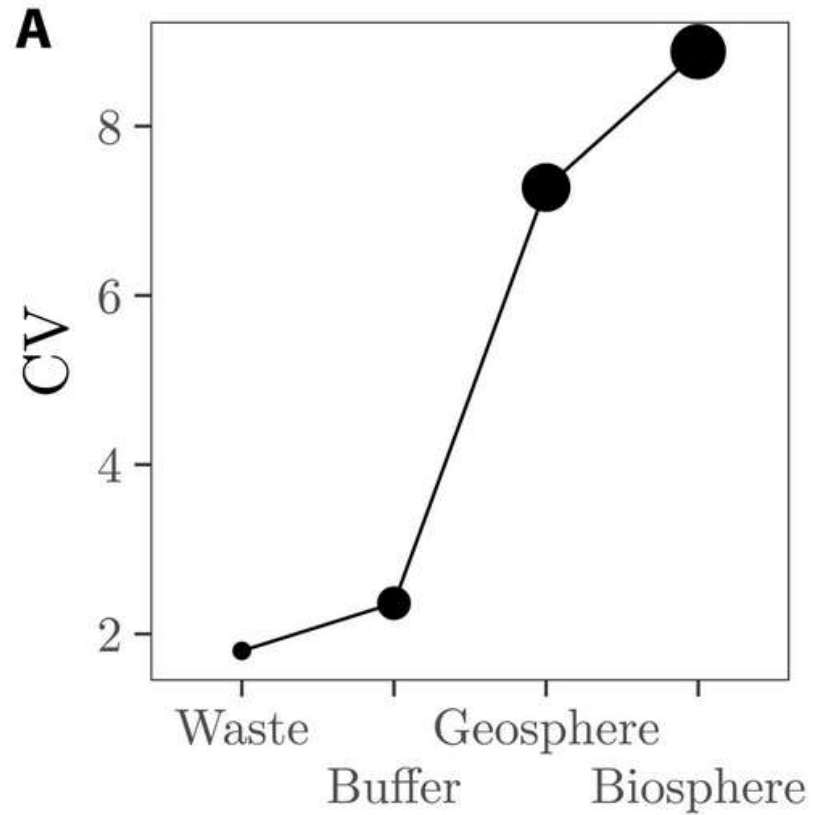
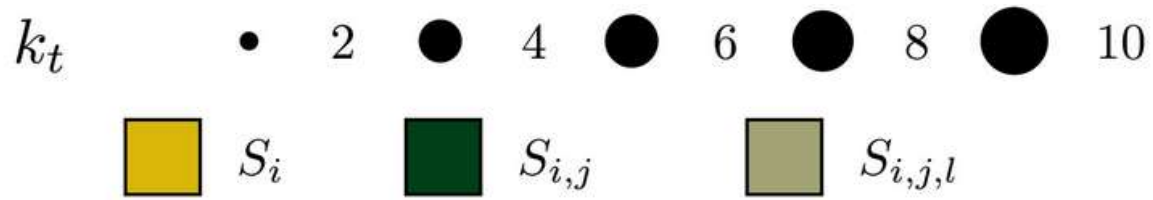
[ARNALD PUY](#) , [PIERFRANCESCO BENEVENTANO](#), [SIMON A. LEVIN](#) , [SAMUELE LO PIANO](#) , [TOMMASO PORTALURI](#), AND [ANDREA SALTELLI](#)  [Authors Info &](#)

[Affiliations](#)

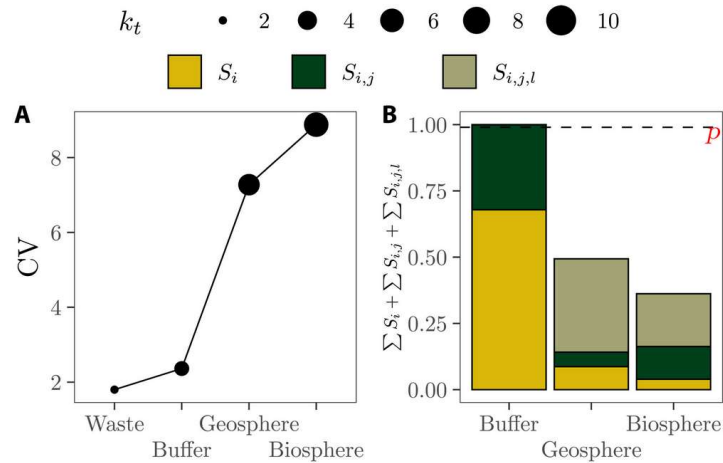


A typical nuclear waste disposal concept: the waste is separated from humans by a series of barriers

Source: World Nuclear Organization, <https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-waste/storage-and-disposal-of-radioactive-waste.aspx>



Propagating uncertainty across the barriers increases variability (CV=std/mean), effective dimension (k_t) and the importance of interactions (S_{ij} , S_{ijk})



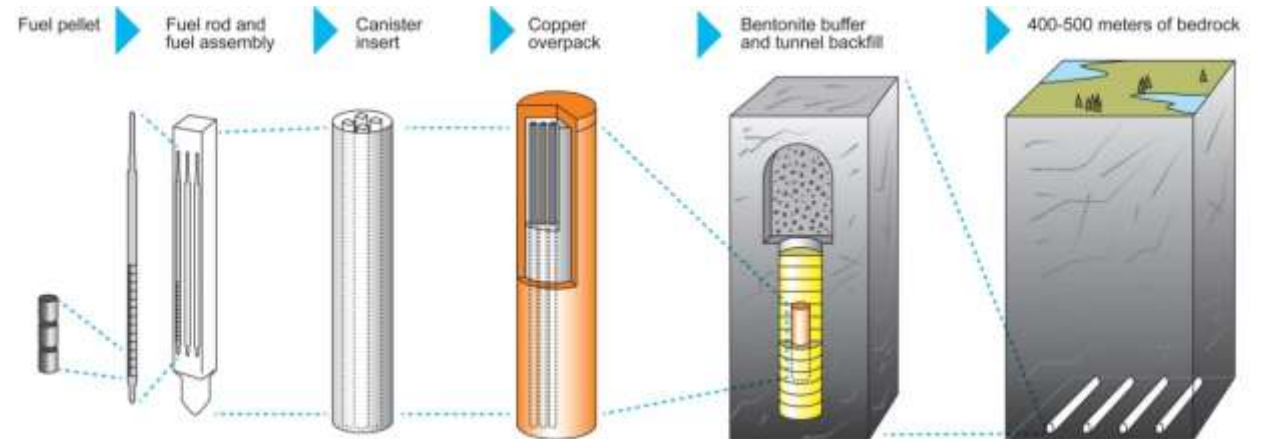
The regulation should not set limits on doses to humans in the biosphere, as done e.g. in the US, since these are impossible to predict with any certainty

A more realistic and defensible safety standard could be set as a maximum level of radioactivity leaving the buffer

Models with higher effective dimensions tend to produce more uncertain estimates

ARNALD PUY, PIERFRANCESCO BENEVENTANO, SIMON A. LEVIN, SAMUELE LO PIANO, TOMMASO PORTALURI, AND ANDREA SALTIELLI

Affiliations



Mind the assumptions

Assess uncertainty and sensitivity

Mind the hubris

Complexity can be the enemy of relevance



Mind the framing

Match purpose and context

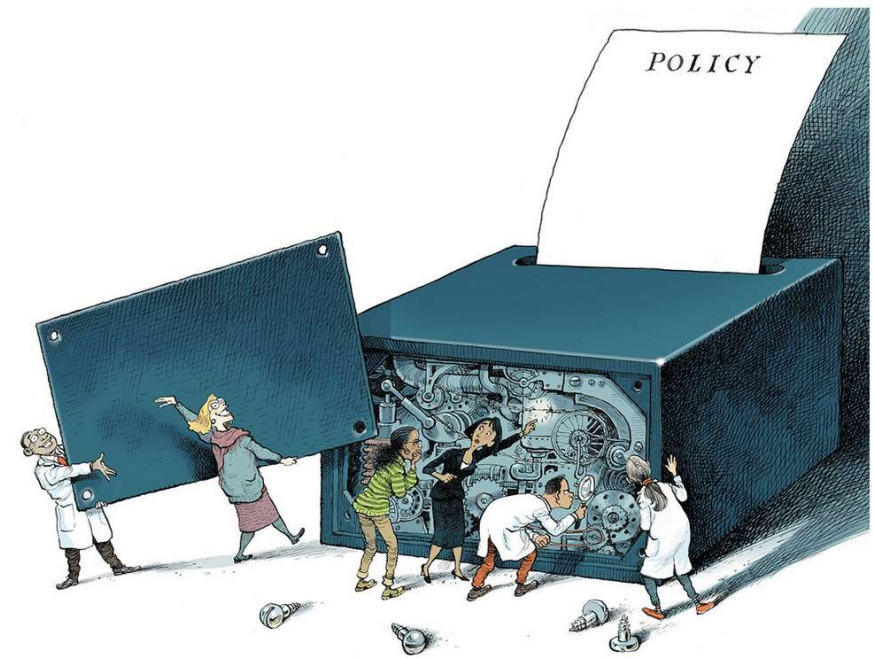


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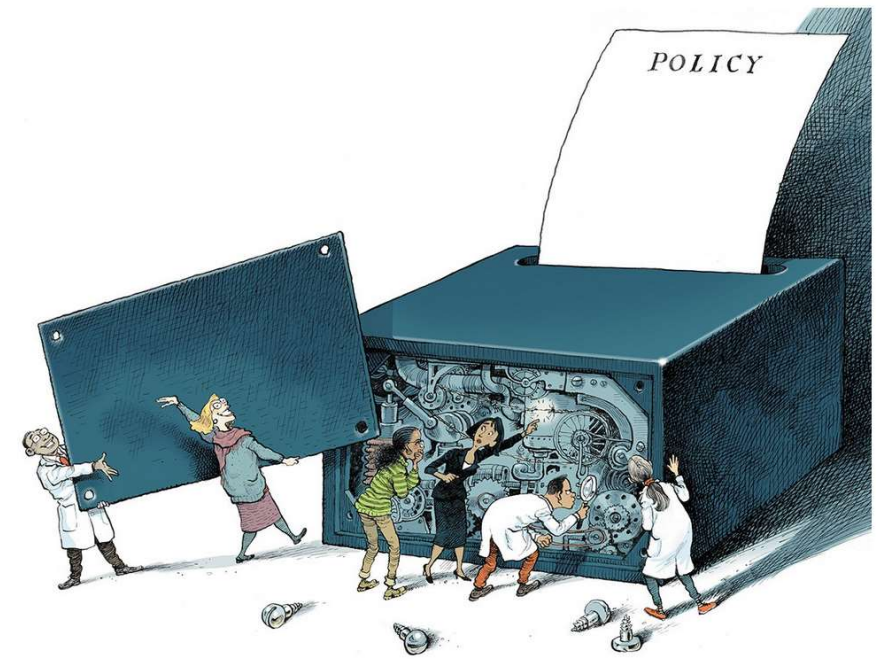
Mind the unknowns

Acknowledge ignorance



Mind the framing

Match purpose and context



… models will reflect the interests, disciplinary orientations and biases of the developers…

SUPPLEMENTARY INFORMATION

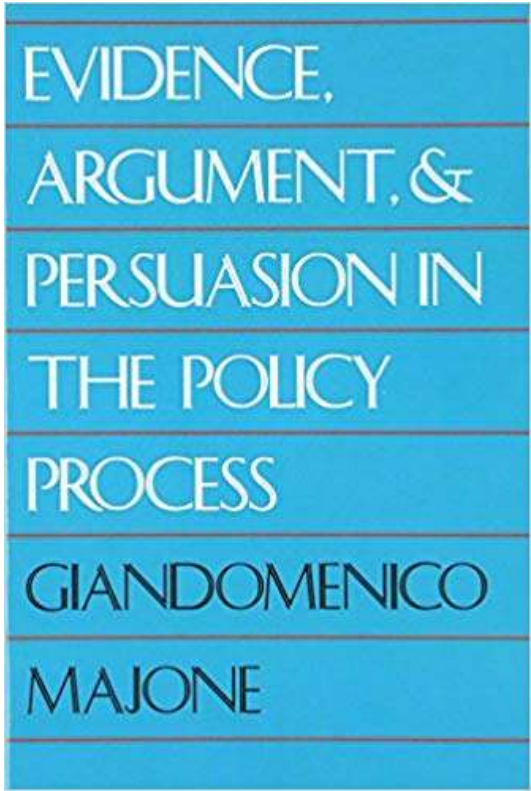
1. [Additional information and references](#)

>260 references

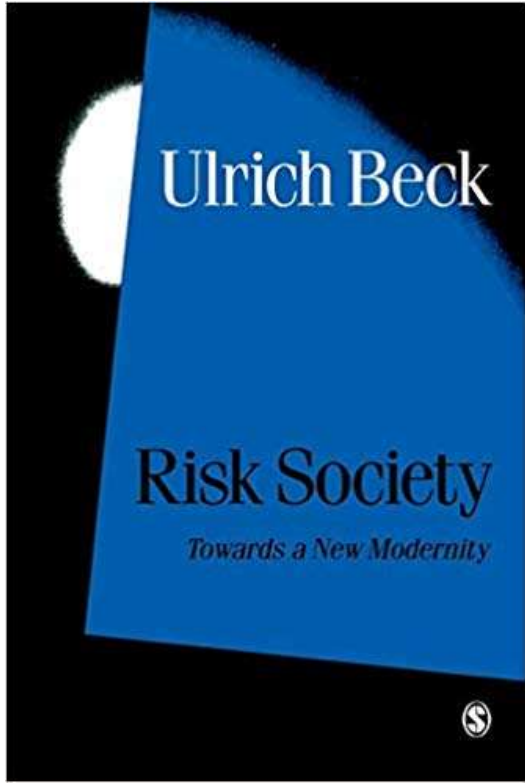
From Ulrich Beck to Giandomenico Majone: the technique is never neutral



Ulrich Beck
(1944 –2015)



1989



1992 (1986)



Environmental Science & Policy

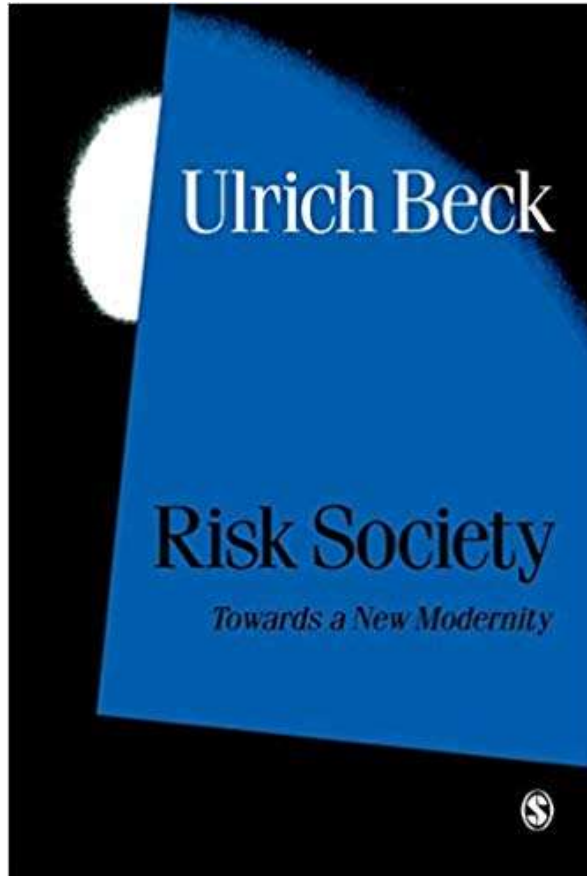
Volume 106, April 2020, Pages 87-98



The technique is never neutral. How methodological choices condition the generation of narratives for sustainability

Andrea Saltelli ^{a, b} ✉, Lorenzo Benini ^c, Silvio Funtowicz ^a, Mario Giampietro ^{d, e}, Matthias Kaiser ^a, Erik Reinert ^{a, f}, Jeroen P. van der Sluijs ^{a, g, h}

“It is not uncommon for political programs to be decided in advance simply by the choice of what expert representatives are included in the circle of advisers.”



1992 (1986)



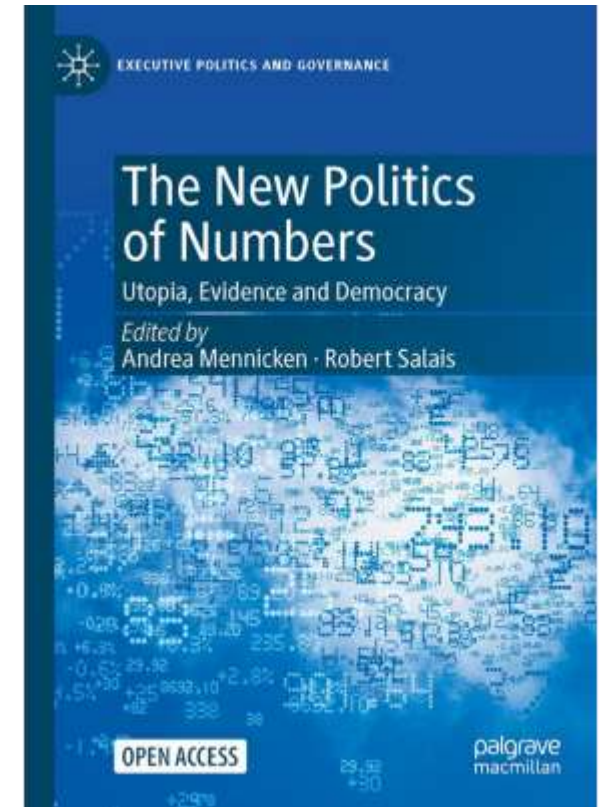
Ulrich Beck
(1944 –2015)

Since the technique is never neutral a technical proof of quality is illusory without a parallel investigation of normative quality

Technical Quality

Normative quality

How the numbers of neoliberalism (New Public Management) constitute a regime of a-democracy; the example of indicators of employment

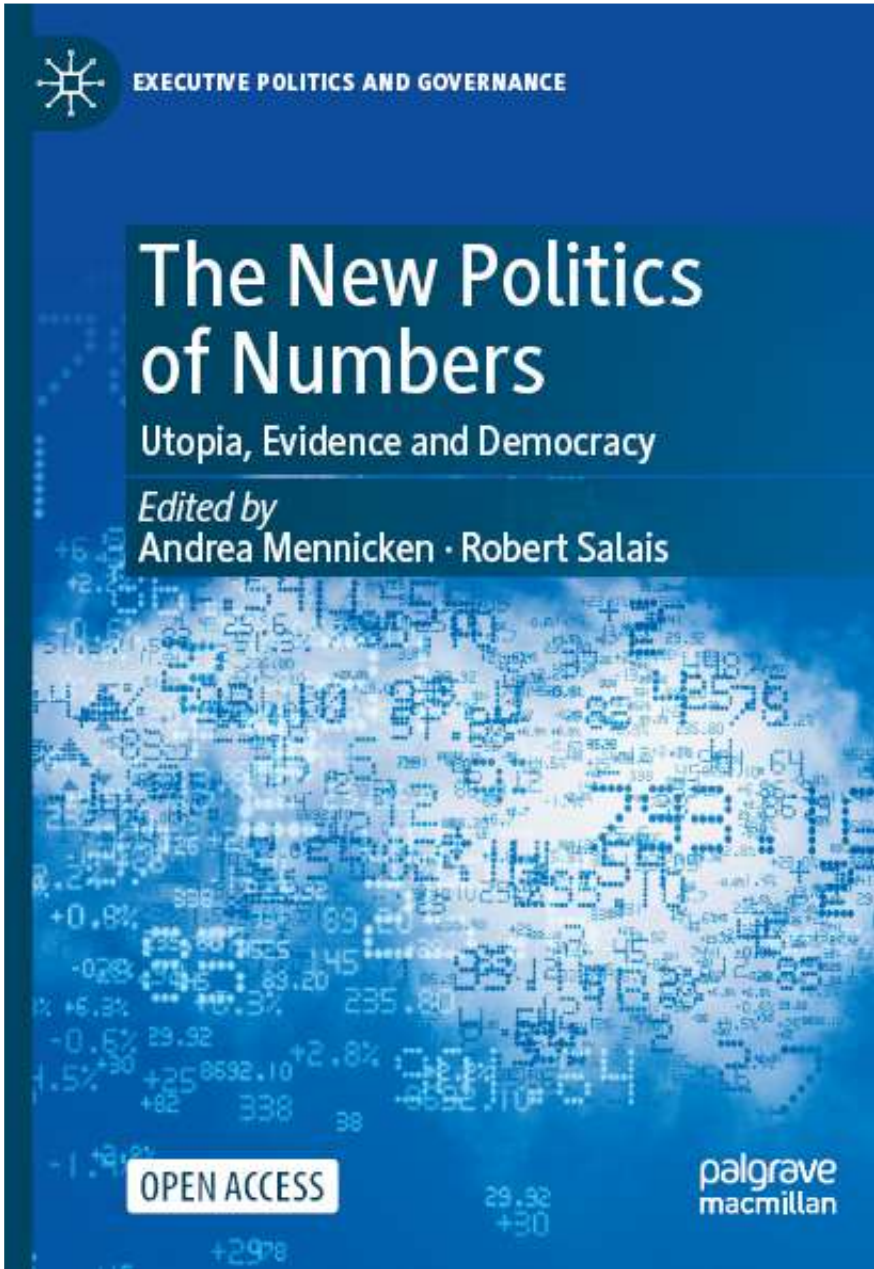


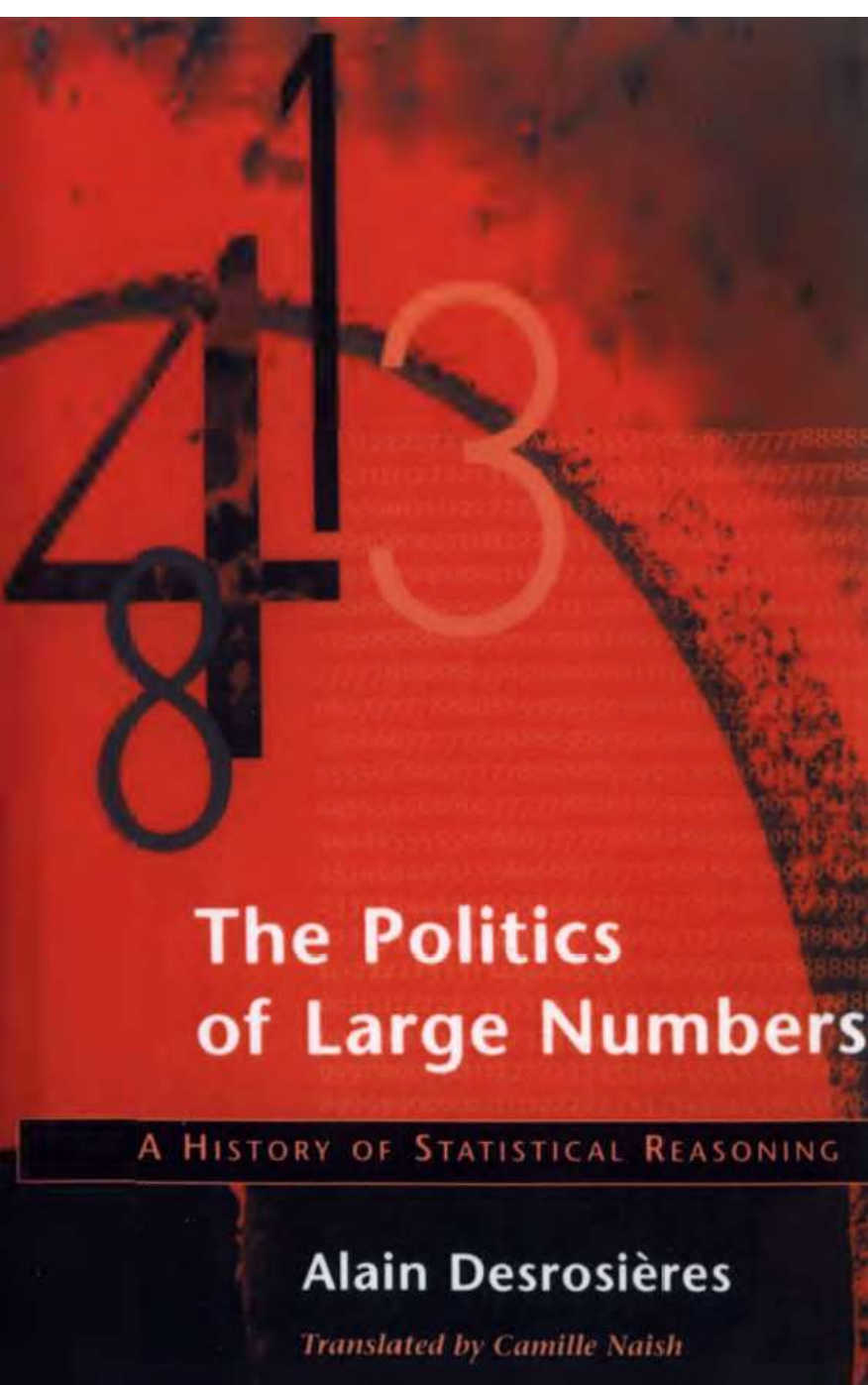
Salais, R. (2022). “La donnée n’est pas un donné”: Statistics, Quantification and Democratic Choice. In *The New Politics of Numbers: Utopia, Evidence and Democracy*, Andrea Mennicken and Robert Salais, Palgrave Macmillan, pp. 379–415.



<p>Evidence based policy</p>	<p>Statistics (creating things that hold together for the solution of practical problems)</p>
<p>Policy based evidence</p>	<p>Governance driven quantification (a reversal of the statistical pyramid)</p>

CHAPTER 12, “La donnée n’est pas un donné”: Statistics, Quantification and Democratic Choice, *Robert Salais*





Alain Desrosières: “Making things that hold”

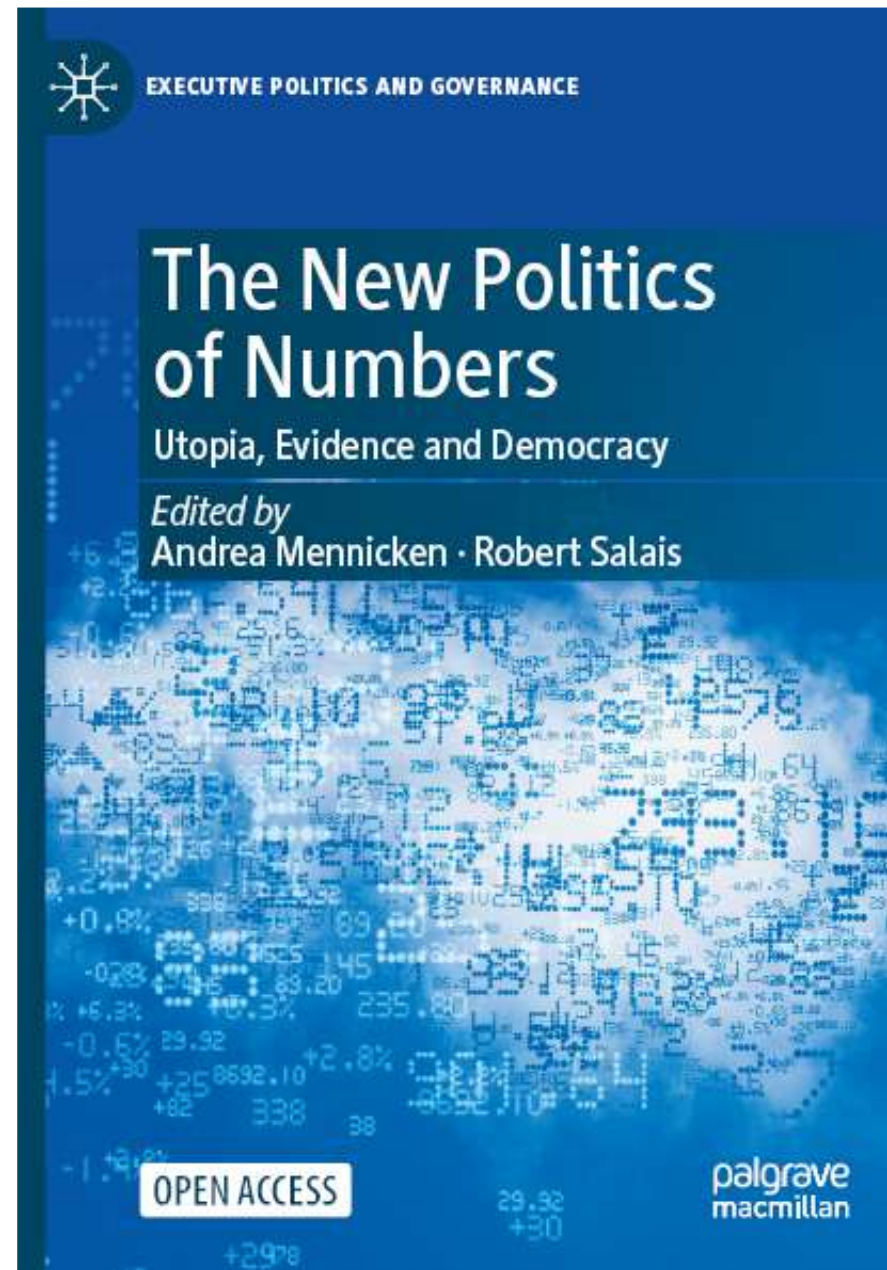
The construction of statistical concepts and categories that can serve for action

BUT

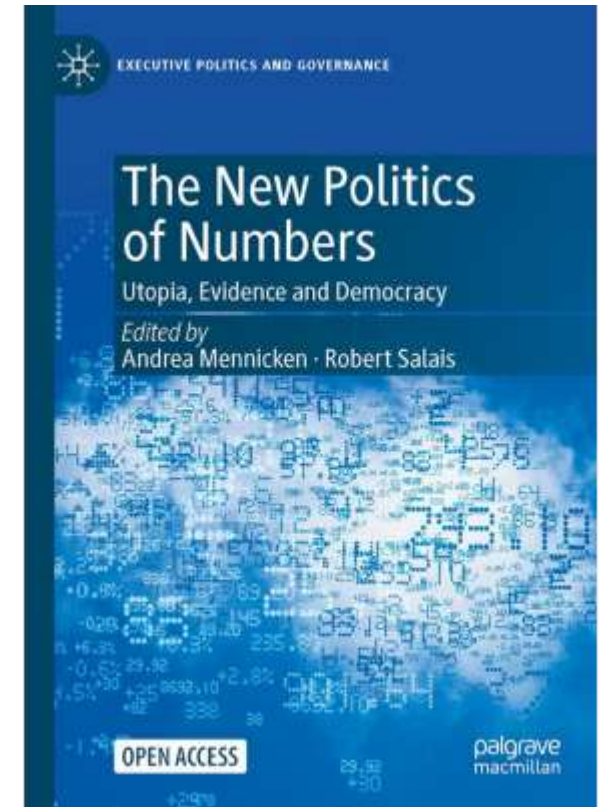
“It is because the moment of objectification can be made autonomous that the moment of action can be based on firmly established objects”

Governance driven quantification is based on pretended objectivity (neutrality), reductionism and justificationism that contribute to a loss of democratic agency (a-democracy)

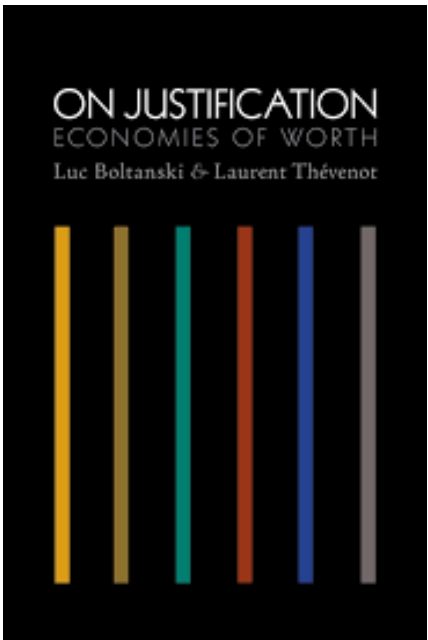
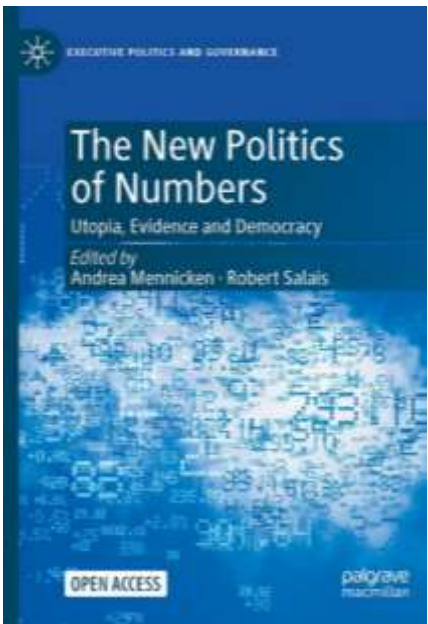
CHAPTER 12, “La donnée n’est pas un donné”: Statistics, Quantification and Democratic Choice, *Robert Salais*



Normative quality ... yes but which norms?



Thévenot, L. (2022). A New Calculable Global World in the Making: Governing Through Transnational Certification Standards. In *The new politics of numbers*, Andrea Mennicken and Robert Salais, Palgrave Macmillan, pp. 197–252.



A New Calculable Global World
in the Making: Governing Through
Transnational Certification Standards

Laurent Thévenot

critical public debates between
conceptions of the common good



individual consumers' choices
between certified market goods



Mind the assumptions

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Mind the hubris

Complexity can be the enemy of relevance

Mind the framing

Match purpose and context

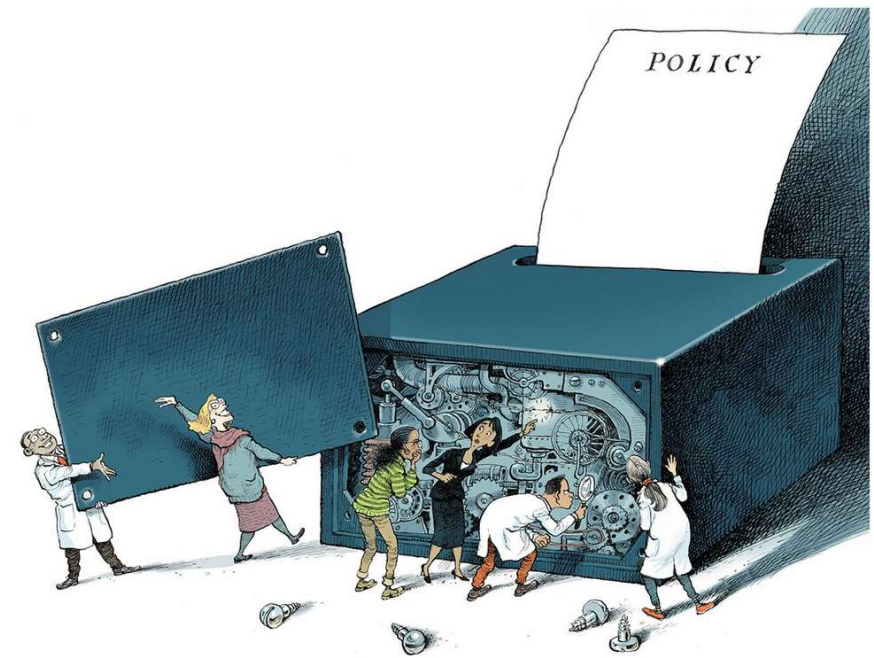


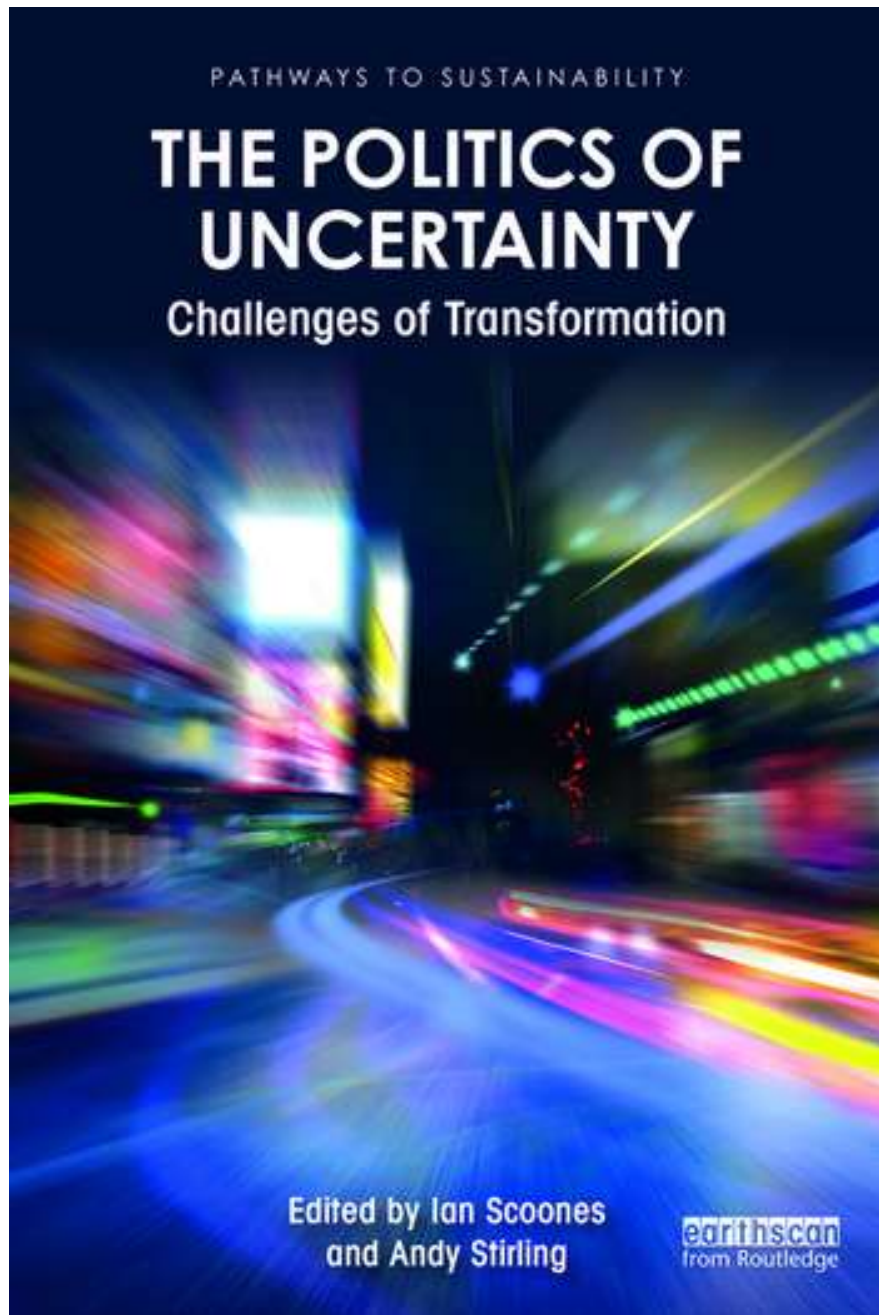
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3

SHARING RISKS OR PROLIFERATING UNCERTAINTIES?

Insurance, disaster and development

Leigh Johnson

Model-based parametric insurance led to dramatic consequences for developing countries experiencing draughts

Open access: <https://www.taylorfrancis.com/books/politics-uncertainty-ian-scoones-andy-stirling/e/10.4324/9781003023845>

A recipe: ‘falsification’ of the available options based on:

- Feasibility (compatibility with external constraints),
- Viability (compatibility with internal constraints), and
- Desirability (compatibility with normative values adopted in the given society)



Futures

Volume 91, August 2017, Pages 62-71



Original research article

What is wrong with evidence based policy, and how can it be improved?

Andrea Saltelli ^{a, b, c, d, e}, Mario Giampietro ^{a, c, d}

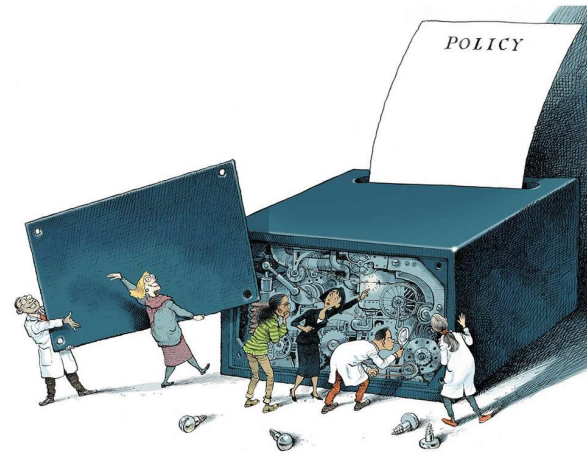
nature

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COMMENT | 24 June 2020

Five ways to ensure that models serve society: a manifesto



2020

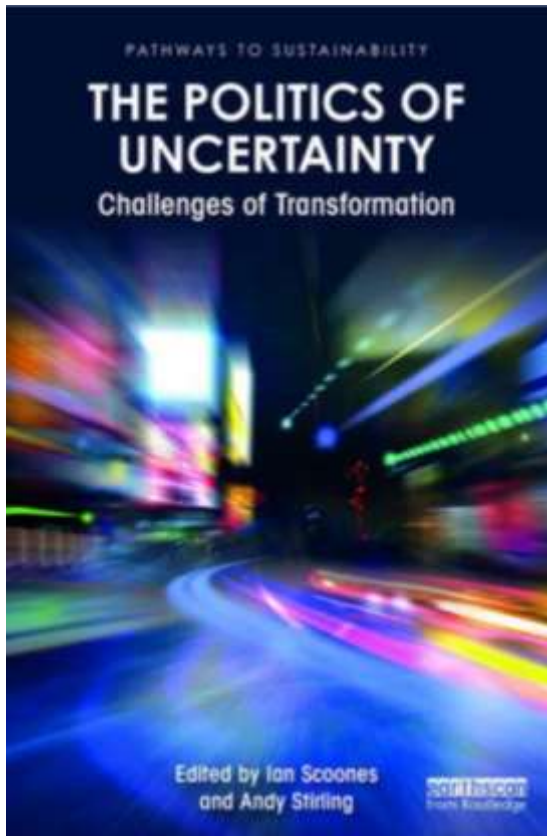
2023



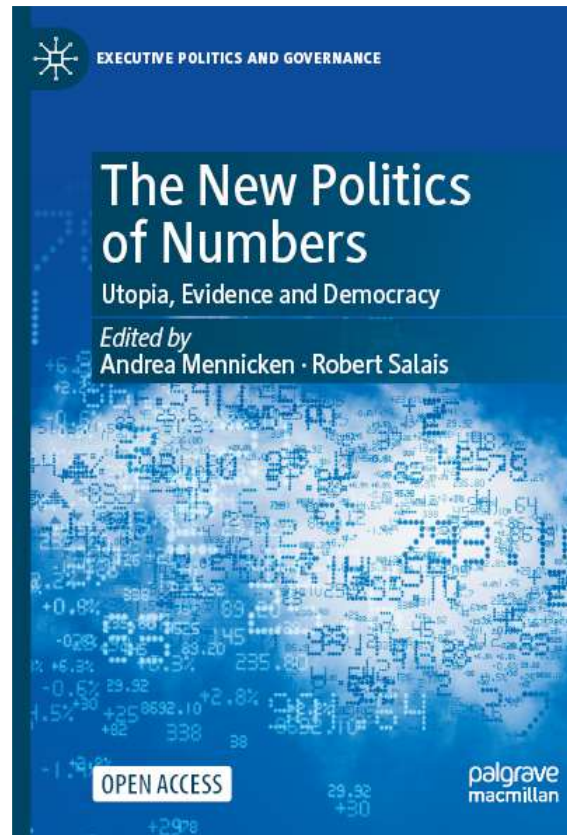
→ Reciprocal domestication between models and society

2024

A screenshot of the Taylor & Francis Online website. The page is for the article 'Mathematical models: a state of exception' by Andrea Saltelli, Arnald Puy, and Monica Di Fiore. The article is published in the 'International Review of Applied Economics'. The page shows the article title, authors, and publication details. There are buttons for 'Submit an article', 'journal homepage', 'Full Article', 'Figures & data', 'References', 'Citations', 'Metrics', 'Licensing', and 'Reprints & Permissions'. The article has 904 views, 0 CrossRef citations, and 2 Altmetric mentions. The DOI is 10.1080/02692171.2024.2365727.



2020



2022



2023

Goal: Reveal the policy of (mathematical modelling's) numbers

What can mathematical modelling contribute to a sociology of quantification?

[Andrea Saltelli](#) & [Arnald Puy](#)

Humanities and Social Sciences Communications **10**, Article number: 213 (2023) | [Cite this article](#)

448 Accesses | 4 Altmetric | [Metrics](#)

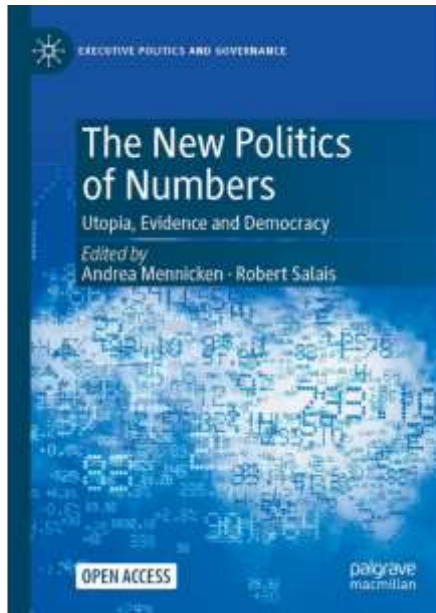
Technical Quality

Normative quality



Sensitivity analysis

Sensitivity auditing



Uncertainty analysis: the study of the uncertainty in model output—see also uncertainty cascade

Sensitivity analysis: the study of the relative importance of different input factors on the model output

Sensitivity auditing : “Sensitivity auditing is a wider consideration of the effect of all types of uncertainty, including structural assumptions embedded in the model, and subjective decisions taken in the framing of the problem” (European Commission, 2021).

Why is all this important? Fishing expeditions and forking paths ...





Jorge Luis Borges
(1899–1986)



Taking different
narratives within the
same novel like Ts'ui Pên

The garden of forking paths: Why multiple comparisons can be a problem, even when there is no “fishing expedition” or “p-hacking” and the research hypothesis was posited ahead of time*

Andrew Gelman[†] and Eric Loken[‡]

14 Nov 2013

The garden of forking paths: Why multiple comparisons can be a problem, even when there is no “fishing expedition” or “p-hacking” and the research hypothesis was posited ahead of time*

Andrew Gelman[†] and Eric Loken[‡]

14 Nov 2013

Why this matters?



PNAS

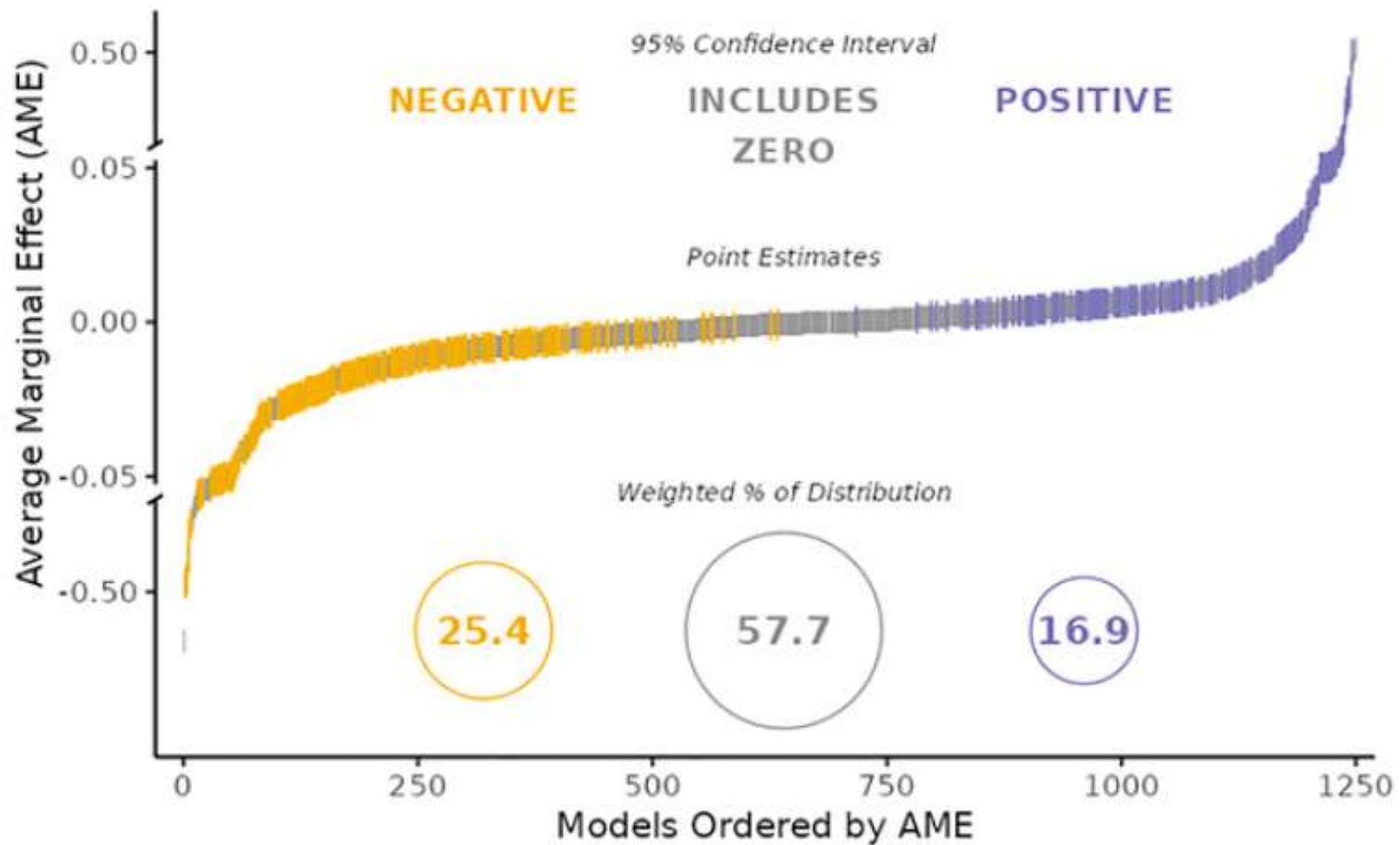
RESEARCH ARTICLE

SOCIAL SCIENCES

 OPEN

Observing many researchers using the same data and hypothesis reveals a hidden universe of uncertainty

Edited by Douglas Massey, Princeton University, Princeton, NJ; received March 6, 2022; accepted August 22, 2022



“Will different researchers [73 teams] converge on similar findings when analyzing the same data?”

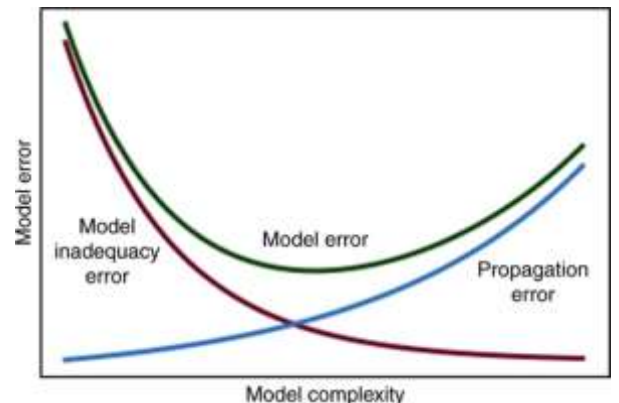
“...teams’ results varied greatly, ranging from large negative to large positive effects”
 (Massey et al. 2022)

Sensitivity analysis and auditing can assist sociology of quantification in activities of de- and re-construction (e.g. for statactivists)



Modelling of the modelling process, to

- ➔ retrace what was assumed
- ➔ check the level of complexity
- ...



...

→ check simultaneously technical and normative quality

Example use SA to ascertain that an algorithm does not make implicit use of protected attributes

PROTECTED ATTRIBUTES:

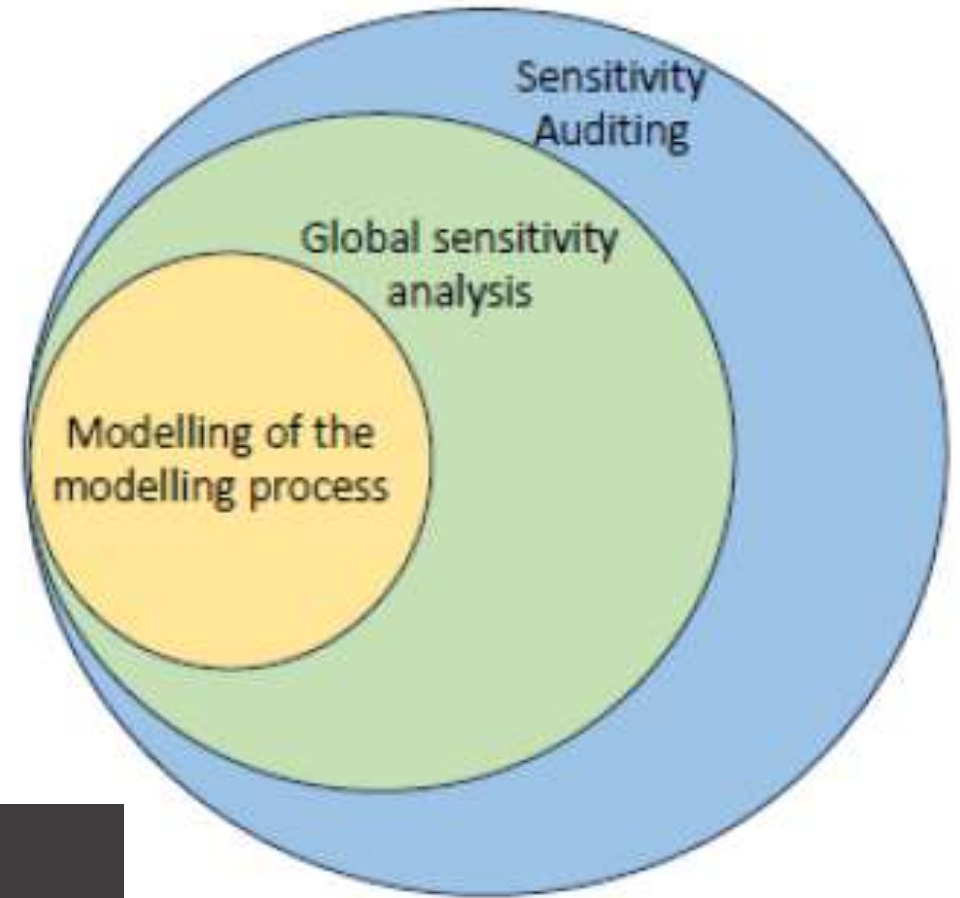
- Age
- Disability
- National Origin
- Race/color
- Religion
- Sex
- (From the US Equal Opportunity Employment Commission)

Increasing Transparency Through a Multiverse Analysis

Sara Steegen¹, Francis Tuerlinckx¹, Andrew Gelman², and Wolf Vanpaemel¹

¹KU Leuven, University of Leuven and ²Columbia University

Multiverse analysis \Leftrightarrow Modelling of the modelling process



AUTHORS

Andrea Saltelli, Alessio Lachi, Arnald Puy, and Nate Breznau



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Andrea Saltelli

Leamer reloaded: a long-neglected suggestion is rediscovered to apply global sensitivity analysis to a quantification before publishing it

Solutions:

→ Avoid “quantifying at all costs” AND expose ‘funny numbers’



Culture Unbound

Journal of Current Cultural Research

Funny Numbers

By Theodore M. Porter

... beyond funny



Perspective |  Open Access |  

Bring digital twins back to Earth

Andrea Saltelli  Gerd Gigerenzer, Mike Hulme, Konstantinos V. Katsikopoulos, Lieke A. Melsen, Glen P. Peters, Roger Pielke Jr, Simon Robertson ... [See all authors](#) 

First published: 26 August 2024 | <https://doi.org/10.1002/wcc.915>

Edited by Matthias Heymann, Domain Editor and Maria Carmen Lemos, Editor-in-Chief

Scientists have built a 'digital twin' of Earth to predict the future of climate change



By [Rosie Frost](#) & [Angela Symons](#)

Published on 11/06/2024 - 16:00 GMT+2 • Updated 16:00

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The complex computer model takes into account weather and climate systems as well as our impact on the planet.

DestinE is true game changer in our fight against climate change. ”

- Margrethe Vestager -

"The launch of the initial Destination Earth (DestinE) is a true game changer in our fight against climate change," says Margrethe Vestager, Executive Vice-President for a Europe Fit for the Digital Age. "It means that we can observe environmental challenges which can help us **predict** future scenarios - like we have never done before... Today, the future is literally at our fingertips."

Margrethe Vestager



YOU CONTROL CLIMATE CHANGE.

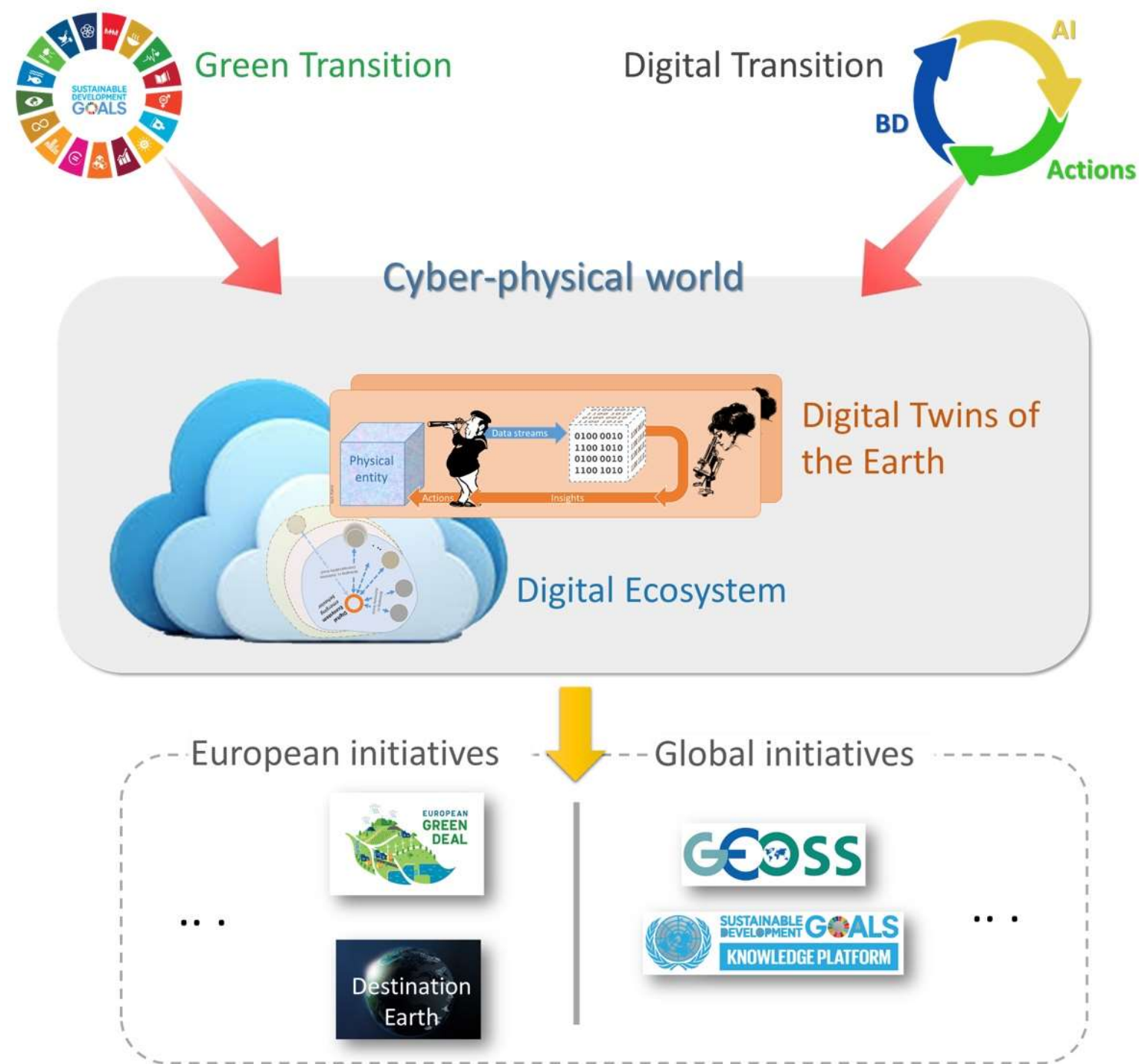


www.climatechange.eu.com

TURN DOWN. SWITCH OFF. RECYCLE. WALK. **CHANGE**

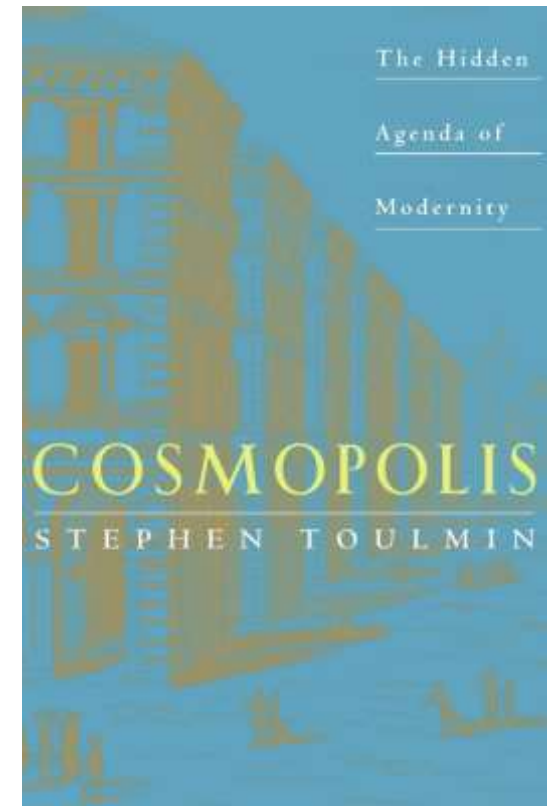
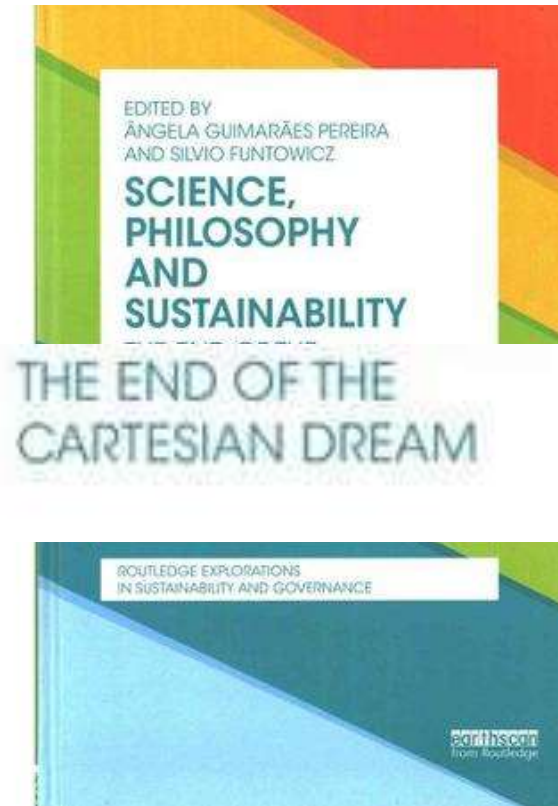
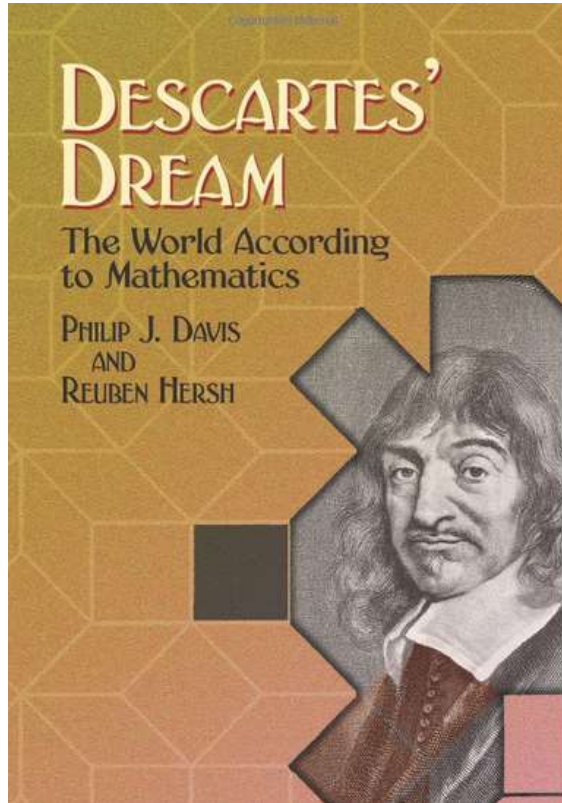
Digital Twins of the Earth

[...] with the advent of the Digital Transformation, the interconnection between the physical and the digital world has become almost complete: economic, industrial, and social relationships have been moved to the “cyber-physical” world ...



Source: S. Nativi, P. Mazzetti, and M. Craglia, 'Digital Ecosystems for Developing Digital Twins of the Earth: The Destination Earth Case', Remote Sensing, vol. 13, no. 11, Art. no. 11, Jan. 2021, doi: 10.3390/rs13112119

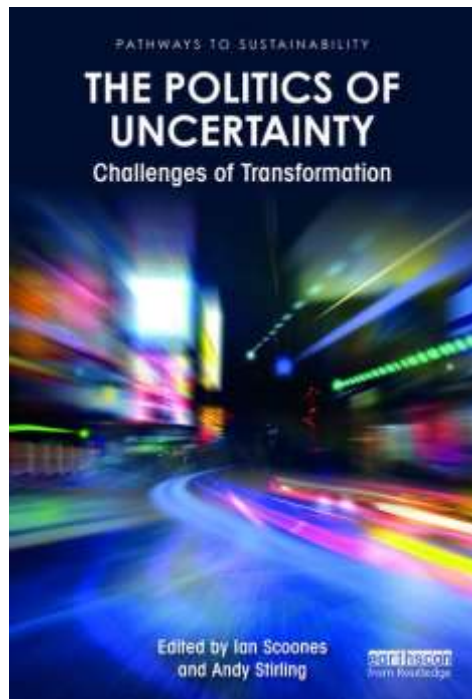
Digital Twins: The planet as a manufact; the ultimate Cartesian Dream



DT's assumes that climate change needs more evidence to promote political agency, and that said evidence can come in the form of DT's

Problems with DestinE

The EC leans toward technology as a conduit to solve policy problems → European institutions are vulnerable to projects oriented to technological solutions and technological optimism



4

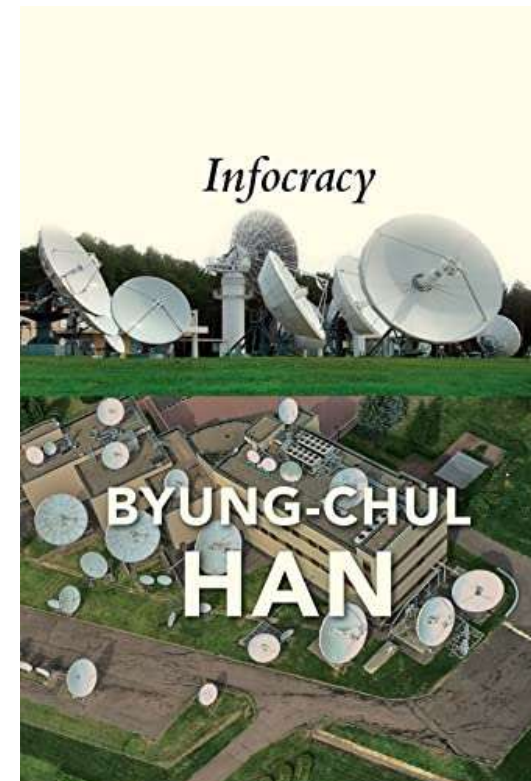
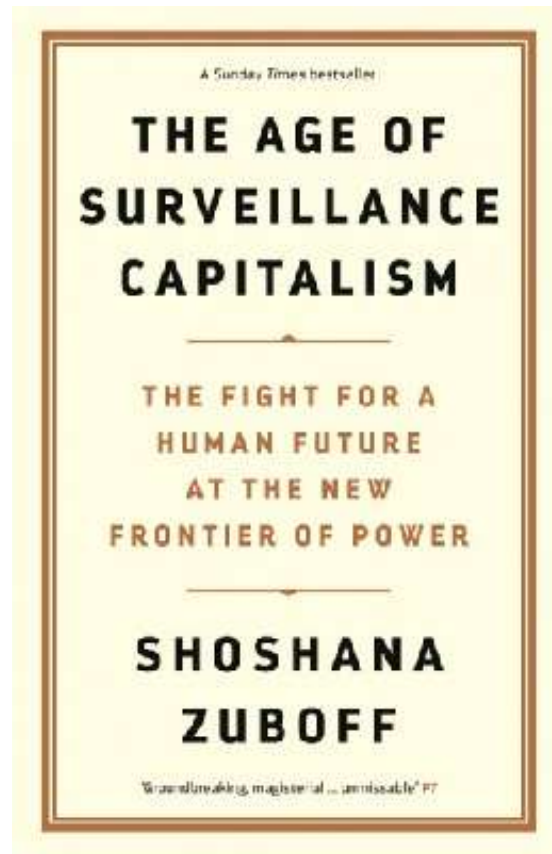
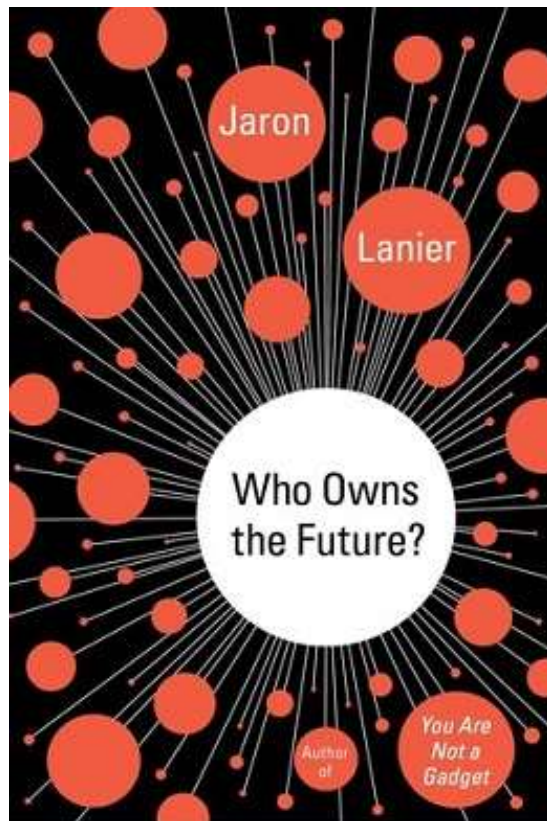
THE UNRAVELLING OF TECHNOCRATIC ORTHODOXY?

Contemporary knowledge politics
in technology regulation

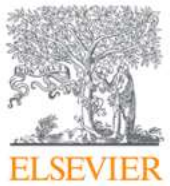
Patrick van Zwanenberg

Problems with DestinE

The epistemic community around DestinE unexposed to the concerns about the digitalization of the real



‘expected utility’, ‘decision theory’, ‘life cycle assessment’, ‘ecosystem services’ ‘sound scientific decisions’ and ‘evidence-based policy’ ... profusion of digits, promises of accuracy



Research Policy

Available online 21 December 2022, 104709

In Press, Corrected Proof



Discussion

Against misleading technocratic precision in research evaluation and wider policy – A response to Franzoni and Stephan (2023), ‘uncertainty and risk-taking in science’

Andy Stirling



Andrew Stirling

Problems with DestinE: A-la-Zuckerberg approach to introducing new technologies: first it is done, then one worries about “How to embed the ethical, legal, and social considerations in the Digital Twin of the Earth and its interface, such as privacy, equity, accessibility ...”



Don't forget 2013 EC's Human Brain Project

“the European Commission awarded ... a staggering 1 billion euro grant ... the people I contacted struggled to name a major contribution that the HBP has made in the past decade” (Yong, 2019)

nature

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Published: 03 September 2014

Neuroscience: Where is the brain in the Human Brain Project?

[Yves Frégnac](#) ✉ & [Gilles Laurent](#) ✉

[Nature](#) 513, 27–29 (2014) | [Cite this article](#)

Newsletters

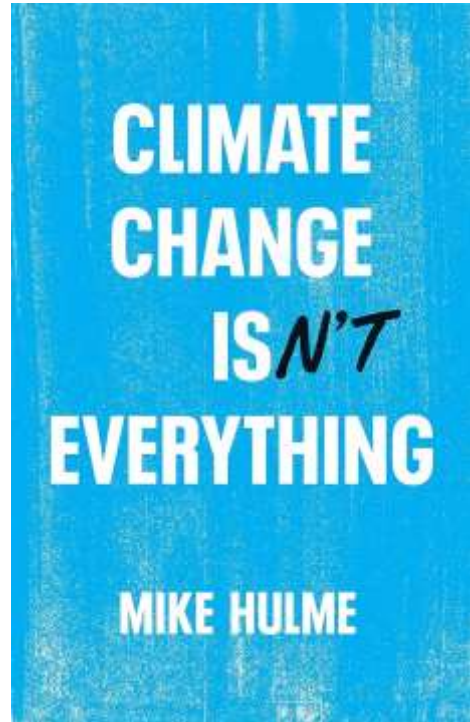
The Atlantic

SCIENCE

The Human Brain Project Hasn't Lived Up to Its Promise

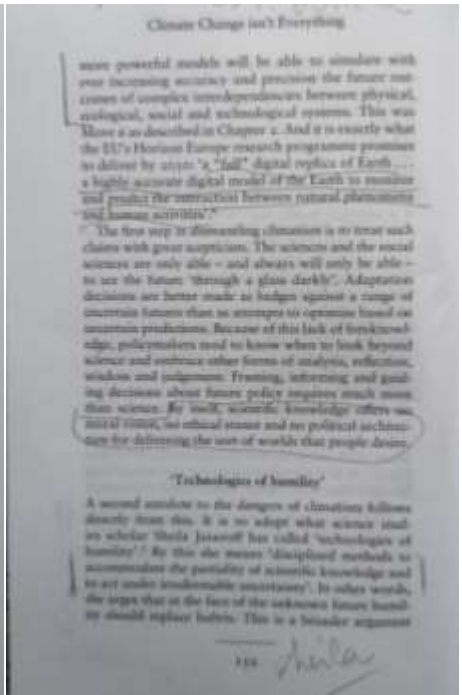
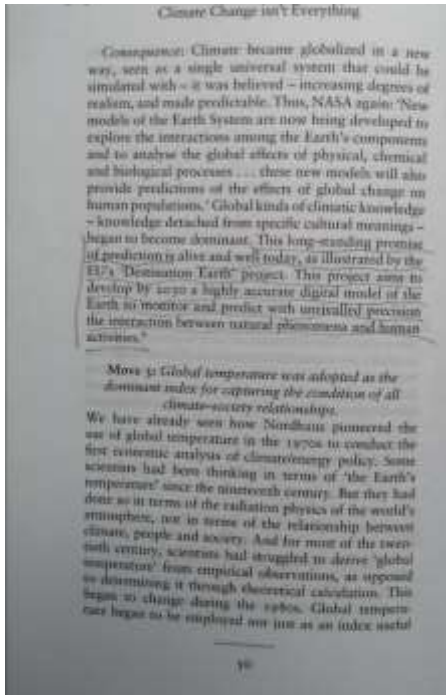
Ten years ago, a neuroscientist said that within a decade he could simulate a human brain. Spoiler: It didn't happen.

By Ed Yong JULY 22, 2019



Climate change cannot be the lens through which to look at the world's problems. The war in Syria is not a result of climate change

Rejecting climatic determinism is not a refutation of climate change but of its instrumental use



“Climate became globalized in new ways, seen as a single universal system that could be simulated with increasing degree of realism and made predictable ... knowledge detached from specific cultural meanings... p. 50

The EU Horizon Europe research programme promises to deliver by 2030 “a full replica... a highly accurate digital model of the Earth to monitor and predict the interactions between natural phenomena and human activities” p. 130



Hulme, Mike. 2023. *Climate Change Isn't Everything: Liberating Climate Politics from Alarmism*. 1st edition. Medford: Polity.

planet is secured. In continuing to react to problems as they emerge with incremental changes, making many missteps along the way. Ambitious visions to manage the Earth's physical and social complexity – whether using the promise of the EU's Destination Earth, machine learning or artificial intelligence – are chimeras. And a humbler disposition



Ambitious visions to manage the Earth's physical and social complexity – whether using the promise of the EU's Destination Earth, machine learning or artificial intelligence – are chimeras



DT's are marketed as a source of 'climate intelligence' but if it is true that "Financial markets and private companies, are in an "arms race" for climate intelligence" [*], should this race be met with public funds?

[*] L. Harris, "Rise of the Climate Rating Agencies," *The American Prospect*, Apr. 12, 2023. Accessed: Jun. 07, 2023. [Online]. Available: <https://prospect.org/api/content/6015e258-d87d-11ed-bd1d-12163087a831/>

Could climate intelligence backfire? Consider the effects of mortgage securitization on the the last housing bubble recession started in 2007



Performing Climate Risks to Financial Stability

Are climate change models the source of our next financial crisis?

MAY 17, 2024

PRINT

SHARE

As the dust of the global financial crisis of 2007–08 settled, many of those looking for someone to blame for the economic disaster zeroed in on something called the Gaussian copula model, a family of mathematical functions used to estimate the probability distribution of investment losses. In a [lament](#) on Wired, for example, the journalist Felix Salmon wrote that the model had become “so deeply entrenched—and was making people so much money—that warnings about



Jessica Weinkle

Problems with DestinE

The engagement of social science and humanities that gets accepted in journals seems to be of a confirmatory nature – to help the actors of DestinE to receive societal consensus

For example:

Purportedly a critique but ...



communications earth & environment

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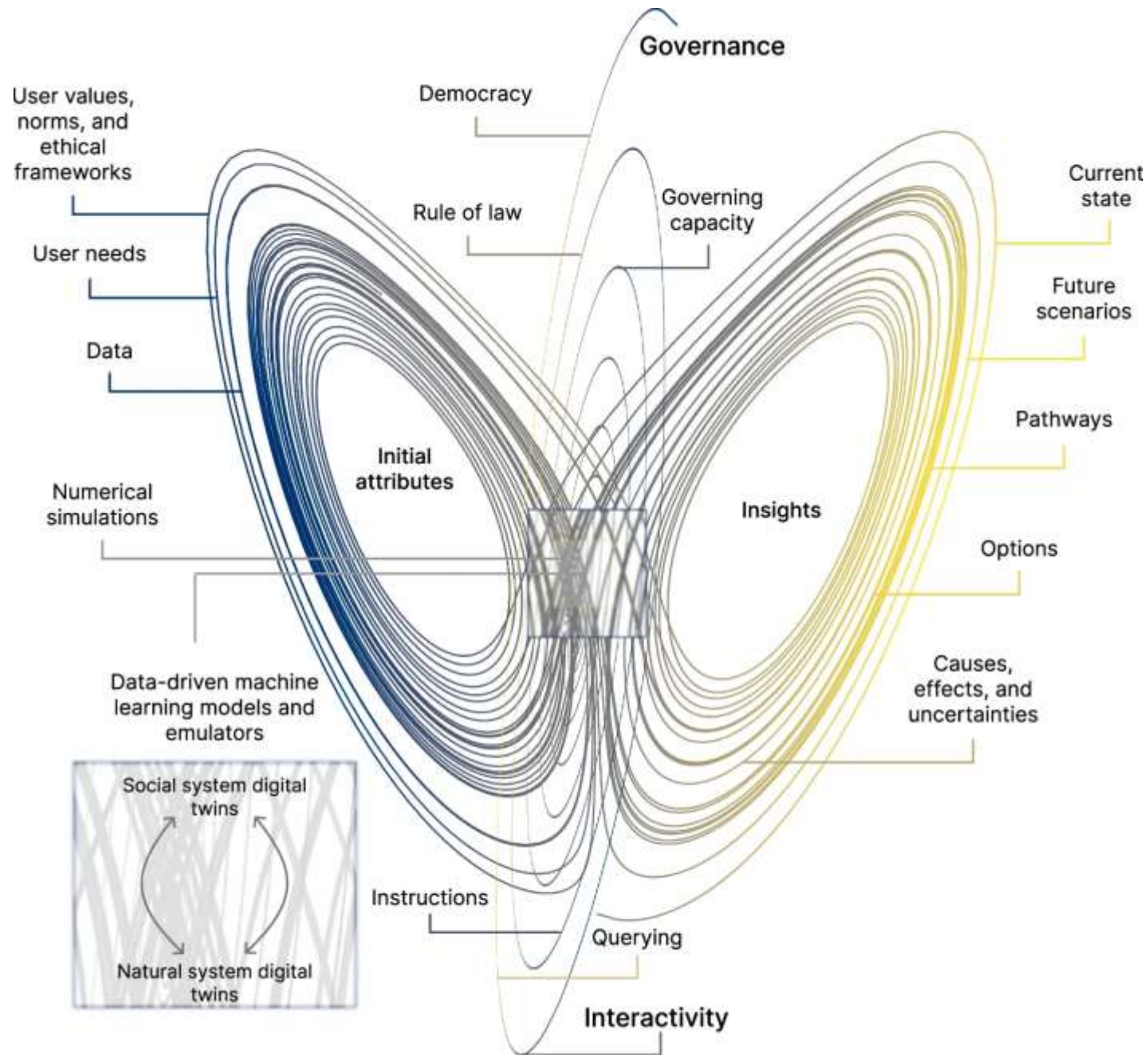
Perspective | [Open access](#) | Published: 27 August 2024

Digital twins of the Earth with and for humans

[W. Hazeleger](#) , [J. P. M. Aerts](#), [P. Bauer](#), [M. F. P. Bierkens](#), [G. Camps-Valls](#), [M. M. Dekker](#), [F. J. Doblas-Reyes](#), [V. Eyring](#), [C. Finkenauer](#), [A. Grundner](#), [S. Hachinger](#), [D. M. Hall](#), [T. Hartmann](#), [F. Iglesias-Suarez](#), [M. Janssens](#), [E. R. Jones](#), [T. Kölling](#), [M. Lees](#), [S. Lhermitte](#), [R. V. van Nieuwpoort](#), [A.-K. Pahker](#), [O. J. Pellicer-Valero](#), [F. P. Pijpers](#), [A. Siibak](#) ... [F. C. Vossepoel](#) [+ Show authors](#)

[Communications Earth & Environment](#) **5**, Article number: 463 (2024) | [Cite this article](#)

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Digital twins of the Earth with and for humans

[W. Hazeleger](#) , [J. P. M. Aerts](#), [P. Bauer](#), [M. F. P. Bierkens](#), [G. Camps-Valls](#), [M. M. Dekker](#), [F. J. Doblas-Reyes](#), [V. Eyring](#), [C. Finkenauer](#), [A. Grundner](#), [S. Hachinger](#), [D. M. Hall](#), [T. Hartmann](#), [F. Iglesias-Suarez](#), [M. Janssens](#), [E. R. Jones](#), [T. Kölling](#), [M. Lees](#), [S. Lhermitte](#), [R. V. van Nieuwpoort](#), [A.-K. Pahker](#), [O. J. Pellicer-Valero](#), [F. P. Pijpers](#), [A. Siibak](#), ... [F. C. Vossepoel](#) [+ Show authors](#)

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“Incorporating human interactions in digital twins of the Earth represents a transformative frontier, promising unparalleled insights into Earth system dynamics and empower humans for action.”

“... researchers might be led by their quest for funds to promote “digital twins” of everything—DTs of biodiversity (BioDT) and of extreme events (DT-GEO) are already in progress—thus overstretching the metaphor ...

...we note that societal concern with pollinator decline is attentive to phenomena of regulatory capture, seen as one of the causes of pesticide-friendly legislation” (not in BioDT)”



Perspective | [Open Access](#) |

Bring digital twins back to Earth

Andrea Saltelli , Gerd Gigerenzer, Mike Hulme, Konstantinos V. Katsikopoulos, Lieke A. Melsen, Glen P. Peters, Roger Pielke Jr, Simon Robertson ... [See all authors](#) ▾

First published: 26 August 2024 | <https://doi.org/10.1002/wcc.915>

Edited by Matthias Heymann, Domain Editor and Maria Carmen Lemos, Editor-in-Chief



Current Opinion in Insect Science

Volume 46, August 2021, Pages 95-105



Pollinator conservation requires a stronger and broader application of the precautionary principle ☆

[Laura Drivdal](#)¹, [Jeroen P van der Sluijs](#)^{1 2}



Futures

Volume 135, January 2022, 102860



Science, the endless frontier of regulatory capture

[Andrea Saltelli](#)^a , , [Dorothy J. Dankel](#)^{b c}, [Monica Di Fiore](#)^d, [Nina Holland](#)^e, [Martin Pigeon](#)^e

The End



<https://mstdn.social/@AndreaSaltelli/>

Video recorded by UOC:

<https://www.youtube.com/watch?v=eHtJUSxoioI&t=921s>

In the formulation of Condorcet: “All the errors in politics and in morals are founded upon philosophical mistakes, which, themselves, are connected with physical errors” (Ninth Epoch)



Nicolas de Caritat, marquis de
Condorcet
(1743- 1794)

‘Sketch for a Historical Picture of
the Progress of the Human Spirit’

<http://oll.libertyfund.org/titles/1669>

Ethics of quantification

Andrea
Saltelli

